2021

FROM CATCH TO CONSUMPTION: FOOD SECURITY DYNAMICS IN AN INDONESIAN FISHING COMMUNITY

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FROM CATCH TO CONSUMPTION: FOOD SECURITY DYNAMICS IN AN INDONESIAN FISHING COMMUNITY

BY

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

IN

BIOLOGICAL AND ENVIRONMENTAL SCIENCES

UNIVERSITY OF RHODE ISLAND

2021

MASTER OF SCIENCE THESIS

OF

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2021

ABSTRACT

Food and livelihood security are key concerns for coastal communities in Indonesia as local and global drivers threaten fisheries across the archipelago. However, the focus of fisheries management and conservation on fish production excludes important aspects of the fish food system such as local economies, relationships, and cultures. For management and conservation policy to address food insecurity and marine resource declines, there is a need to understand local trade and consumption. In this study, we use value chain analysis and a "fish as food" framework to investigate the links between fish production, distribution, and consumption in an Indonesian fishing community (Bontosua Island, which is near the port city of Makassar). To explore dimensions of food security, we employed value chain surveys spanning trading structures and livelihood benefits (Chapter 2) and household surveys depicting on-island distribution pathways (Chapter 3). Three questions guide the research: i.) What social and economic benefits do actors in the Bontosua-Makassar value chain receive from the fish trade, and what maintains them? (Chapter 2); ii.) Which fisheries are most important for food security (i.e. trade, nutrition, cultural, and social value) on Bontosua? (Chapters 2 and 3); and iii.) In what ways do the island's nutritional dependence on certain fish species and acquisition pathways reflect the local fishing and trading environment? (Chapter 3). The results of this study are also interpreted to advise an ongoing coral restoration project on the island, which was formed with a socio-economic aim to support long-term food security and livelihoods.

We found that trade connected to the study community was market-based and fish were staple items in household diets. Although coral reefs are the main targets for marine

conservation projects like the one occurring on-island, small pelagic (offshore) fish were the dominant fish type present in value chain and household surveys. Fish flows were maintained primarily by pelagic fishing crews, a hierarchical fishing format supported by debt-based ties between a patron (lender) and client (debtor). Debt mediated unequal trade relations, leading boat owners and middlemen to accumulate a majority of the wealth from fish trading. At the household level, access to fish and particular fish species was seasonally dependent: during the windy season, households had higher social and economic vulnerability because fish supplies were limited, fish buying increased, and households had to substitute their preferred wild-caught species with imported farmed fish. Strong associations between dietary diversity and purchased food groups, combined with a market-led, hierarchical fish trade, suggests that improving food security outcomes requires greater investment in trading equity within the fisheries value chain. Given the study island's strong ties to offshore fishing and debt-based relations, a conservation project focused primarily on enhancing populations of coral reef fish is unlikely to generate long-term community benefits tied to food security. Our conclusions underscore the need to more closely examine the dynamics of subsistence, commercial, and cultural use when integrating fisheries conservation and management plans.

ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. Austin Humphries, for guiding and supporting me through the many challenges this research (and the pandemic!) presented. I am grateful to my other committee members, Dr. Brietta Oaks, Dr. Amelia Moore, and Dr. Carlos Garcia-Quijano, for offering their diverse perspectives which have helped this research project take shape. A huge debt of gratitude is owed to the Sociology team at Hasanuddin University-- Dr. Buchari Mengge, Novita Sari, Irsan, Muhammad Rifadly Utina, Arham Icwardanhi, Anugerah, and Muhammad Zulkifli R. Your experience, love, and support has been incredible, and I feel lucky to have been able to learn from you. Novi, *kamu adalah perempuan yang kuat dan mandiri*. To my translator Farhan Muhatar, who went above and beyond his assigned job, I could not have done my research trips without you! Another huge thank you to my dear friend, roommate, and modeling extraordinaire Annie Innes-Gold, who set the gold standard (pun intended) for master's theses in the Humphries Lab and helped keep me sane during the toughest moments. A big thank you to the other members of the Humphries Lab (Lauren Josephs, Elaine Shen, Elle Wibisono, Catie Alves, Paul Carvalho, Kelvin Gorospe, Celeste Venolia, Donna Dimarchopoulou, Rachel Cohn, Ivy Blackmore) for cultivating such an encouraging, creative, and fun work environment. Finally, thank you to my parents, Ruth and David Roberts, and my sister Rachel Roberts, for being the strongest support system throughout my graduate experience.

PREFACE

This dissertation has been prepared in the manuscript format according to guidelines established by the Graduate School of the University of Rhode Island. Chapter 2 has been formatted for submission to the journal *Marine Policy*, and Chapter 3 has been formatted for submission to the journal *Ecology and Society*.

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CHAPTER 1: Introduction

Fisheries are central to subsistence and trade in coastal developing communities (Bene et al. 2007, Bell et al. 2009, Hall et al. 2013, HLPE 2014, Micha et al. 2020). Fish are one of the least expensive yet most nutritious sources of animal protein (Kawarazuka and Bene 2011, Bene et al. 2016), in addition to being one of the only livelihood opportunities where rapid economic development has restricted land and labor access (Bene et al. 2010, Glaser et al. 2015). With research projecting devastating impacts of global stressors (e.g. climate change, industrialization, and overfishing), the role of fisheries in supporting food security- defined as physical, social, and economic access to sufficient safe and nutritious food to meet dietary needs and preferences (FAO 1996)– has never been more prescient (Bell et al. 2009, Cruz-Trinidad et al. 2014). But despite growing interest, gaps remain in our understanding of the links between fish and food security. Fish tend to be conceived in linear economic terms (e.g. price and volume) at the expense of understanding the full range of forces underpinning their use (Charlton et al. 2016, Bene et al. 2019). Similar interpretations of food security frequently drive fisheries management and conservation (Bell et al. 2009, Matthews et al. 2012, Foale et al. 2013). Compounding governance oversights is the relative scarcity of community perspectives in food security research (Taylor et al. 2019). At a time when future access to fish is being threatened by local and global drivers, there is a need to understand the place-based dynamics involved in both local trade and consumption (Noack and Pouw 2015, Taylor et al. 2019).

Fish are foundational to food and livelihood in the country of Indonesia, providing over half of the nation's total protein requirements and employing more than 6

million people (FAO 2014). Habitat degradation, destructive fishing, climate change, foreign fleets, and a growing local and global population are some of the drivers suspected to play a role in degrading coastal ecosystems around the archipelago (Muawanah et al. 2012, Glaser and Glaeser 2014, Ferrol-Schulte et al. 2015, Prescott et al. 2015). Commercialization has been particularly effective at accelerating marine resource declines. Fleet mechanization under the "Blue Revolution" era of the 1960s transitioned fishing practices from subsistence to commercial-scale enterprises, ushering in greater exploitation, fisheries specialization, and market-oriented trade (Deswandi 2012).

In light of the rapid social and ecological change occurring throughout the region, Indonesia has expressed its intention to reduce coastal vulnerability by laying out "managing marine resources for food security" as a goal for the country's Medium Term Development Plan (Ayunda et al. 2018). Many of the resulting conservation strategies have attempted to address social-ecological dimensions of fisheries declines. One of the largest applications to-date, the Coral Triangle Initiative (CTI), encompasses the highly productive marine territories of six Southeast Asian nations including Indonesia (Foale et al. 2013). The CTI strategy includes networks of marine protected areas (MPAs) designed to protect the long-term sustainability of fish stocks. However, many argue that the project and other similar initiatives have had low implementation success because of their narrow focus on fisheries production- and to a lesser extent, market forces- without a sufficient understanding of the cultural, social, and political dynamics that shape the rest of the fisheries system (Christie 2004, Clifton and Foale 2017).

As coral reef degradation worsens across the CTI, scientists have devised several complementary approaches to promote ecosystem recovery. Coral reef restoration (CRR) has become a popular tool for tropical marine management in areas where degradation is advanced (Williams and Graham 2019). Food and livelihood security are increasingly recognized as main objectives of CRR programs, yet a strong ecological agenda often persists in practice (Hein et al. 2019, Boström-Einarsson et al. 2020). While there is significant research dedicated to the ecological implications of CRR (e.g. Abelson 2006, Aswani et al. 2015, Meesters et al. 2015, Ladd et al. 2018), the human component has been understudied (Hein et al. 2017, 2019, Bayraktarov et al. 2019). Like other conservation strategies, CRR tends to assume a linear relationship between fish production and consumption. One example is the focus of Indonesia's conservation initiatives on coral reef ecosystems, which overlooks coastal communities that target offshore pelagic species (Clifton and Foale 2017, Vandenberg et al. 2021). Such assumptions are misaligned with the complex links and motivations underlying Indonesian fish food system (Glaser et al. 2010, Glaeser and Gorris 2018). Assessing the nature of fisheries reliance and relationships is therefore valuable for identifying disparities between local needs and project goals.

Value chain analysis (VCA) can be a useful analytical tool to track the activity of actors participating in the production, marketing, sales, and consumption of a particular product. More recently, its applications have been tied to socio-economic equity (Rosales et al. 2017). However, the standard focus on upstream actors and technical indicators (e.g. price, volume) limits the ability of these analyses to inform social outcomes such as food and livelihood security (Bennett et al. 2018). To support the well-being of coastal

communities in resource management, scholars suggest shifting from a production-oriented focus to a "whole value chain" perspective where fish are considered for their myriad of cultural, social, and economic uses. The resulting framework, known as "fish as food", considers the ways in which fisheries contribute to both distribution and consumption pathways (Olson et al. 2014, Levkoe et al. 2017, Lowitt et al. 2019). Combining VCA and the fish as food framework, the aims of this project were to investigate the links between fish production, distribution, and consumption and their bearing on food security and nutrition in an Indonesian fishing community. This objective was achieved using value chain surveys spanning trading structures and livelihood benefits (Chapter 2) and household surveys depicting on-island distribution pathways (Chapter 3). Three questions attempted to characterize the social and economic factors and outcomes mediating trade and subsistence:

i.) What social and economic benefits do actors in the Bontosua-Makassar value chain receive from the fish trade, and what maintains them? (Chapter 2)

ii.) Which fisheries are most important for food security (i.e. trade, nutrition, cultural, and social value) on Bontosua? (Chapters 2 and 3)

iii.) In what ways does the island's nutritional dependence on certain fish and acquisition pathways reflect the local fishing and trading environment? (Chapter 3)

The questions and findings of this research pay specific attention to the limitations of fisheries conservation and management in provisioning community benefits from fisheries. Since 2015, the island has been home to a CRR project led by a non-profit sustainable development subsidiary of a multinational for-profit corporation. Along with the intent to restore reef coverage around the island, the project sets out to provide

enabling conditions for long-term food and livelihood security. Without understanding the access and utilization dimensions of fisheries resources, a healthier reef may not be sufficient to produce these assumed community benefits (Foale et al. 2013, Fabinyi et al. 2017). To evaluate the potential efficacy of projects like these for locally affected populations, more attention must be placed on the complex relationship between fisheries and community/household well-being (Charlton et al. 2016, Fabinyi et al. 2017).

Chapter 2 investigates trading structures and their influence on livelihood outcomes in the Bontosua-Makassar fish trade. Survey interviews followed the flow of fish from fishers on Bontosua to end traders in Makassar fish markets, examining: i) the influence of trading structure on benefits distribution (value, knowledge flows, and trading relationships, and ii) the dependence for harvest and trade on reef vs. pelagic fish. Questions gauged market prices, fish volumes, profit sharing, and the basis for actor-actor connections.

On-island trade and consumption patterns are the focus of **Chapter 3**. Using household surveys and supplementary data from Chapter 2, we explored: i) the ways in which household dependence (i.e. nutrition and preference) on certain fish species and acquisition pathways are related to the island's harvest and trade environment, and ii) the nature and extent of the roles that fish play in island diets. **Chapter 4** brings together findings from the previous chapters with concluding thoughts and recommendations for marine management and conservation in Indonesia.

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CHAPTER II: Patron-client relationships and livelihood outcomes in an Indonesian fisheries value chain

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Manuscript in preparation for submission to the journal *Marine Policy*.

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Keywords
Patron-client relationships; value chain analysis; social hierarchies; fish trade; livelihoods; Spermonde, Indonesia

Abstract

Fishing is vital to the livelihood of millions in Southeast Asia. High fisheries dependence and climate-induced stressors have presented significant threats to livelihood security in fishing communities. Management solutions for fisheries in the region from governmental and non-governmental organizations, however, tend to narrowly focus on fish production and catch restrictions despite the importance of local economies, relationships, and cultures. For example, the role of informal networks known as patron-client systems are known by scholars and local populations as important drivers of fisheries exploitation patterns in Indonesia. Here, we use value chain analysis to better understand the socioeconomic and cultural factors that mediate fish catch and distribution in a small Indonesian fishing community. The island's social context in a region governed by patron-client systems spurred the following research questions: i) In what ways does the regional fish trading system influence livelihood outcomes in the fisheries value chain?; and ii) How does the current structure of trade align with fisheries and fishing actors on the island? We collected data on species composition, prices, revenue, and buyer/seller relationships from the point of catch to sale in local and regional markets. Our results show that patrons earn disproportionate benefits compared to fishing clients, including higher revenues, greater bargaining power, and flexibility in trading arrangements from their central position as lenders. Small pelagic fish were the primary fish type caught and traded by all value chain actors. Findings also revealed a strong connection between pelagic-based fishing crews and the wider market system, which dictates the trade of fish off-island. Given the links between trading hierarchies, power structures, and fish flows, we argue that efforts to enhance livelihood security within

fisheries and conservation management structures will be largely unsuccessful if not accompanied by measures to reduce trade inequities.

Introduction

Fishing is vital to livelihood in tropical developing countries such as Indonesia. For millions of people living in the Indonesian archipelago, fish are a critical piece of subsistence, market trade, and identity (Foale et al. 2013). However, the rich marine biodiversity and its associated values are under threat from this high dependence combined with a transition to global fishing markets, overharvesting practices, and climate change (Weeratunge et al. 2010, Cruz-Trinidad et al. 2014). Unless a balance is met between marine conservation and livelihood security, maintaining the socio-economic functions of fisheries to support regional coastal populations will be increasingly challenging.

Indonesia employs over 7 million people in the fisheries sector and is the second largest producer of fish worldwide (World Bank 2021). Fishers and fishing communities, however, tend to occupy the lowest economic strata and are thus vulnerable to fluctuations within the fishing sector (Idrus 2009, Cahyagi and Gurning 2018, Statistik 2020). Government data indicate that Indonesia faces the greatest decline in marine fisheries as a result of climate change compared to other nations, with a potential decrease in catch of 20 percent in the next three decades (Cheung et al. 2010). Beyond the direct effects on ecosystem health, pressures on marine resources have increased livelihood vulnerability in the region (Ferrol-Schulte et al. 2015), defined as "the degree to which a system is susceptible to and is unable to cope with adverse effects" (Adger 2006, p. 269). Evidence of this shift has become increasingly apparent since Indonesia's "Blue Revolution" of the 1960s, a nationwide effort to bolster the nation's fish production capacity. Strategies to mechanize fishing fleets came largely at the expense of

traditional small-scale producers (Deswandi 2012, Warren and Steenbergen 2021). There are concerns that subsequent growth in the international fish trade has brought institutional support and beneficial market arrangements to only a few privileged actors, including trading middlemen (MacFadyen and Corcoran 2002, Sharma 2011, Ferse et al. 2012).

The essential and vulnerable nature of fisheries in Indonesia has made enhancing livelihood security a critical task (Ferrol-Schulte et al. 2015, Glaser et al. 2015). However, much of the existing work on fisheries sustainability in Indonesia is focused on managing fish stocks rather than the local value chain and associated cultures and economies (Deswandi 2012). For instance, the most popular strategies for managing fisheries in Indonesia include gear restrictions, marine protected areas (MPAs), and even coral reef restoration (Foale et al. 2013). The Coral Triangle Initiative is one such program aimed at managing fisheries to improve livelihoods and food security through coral reef protection (e.g. MPAs) and restoration. However, attempts to achieve those objectives have drawn criticism for a lack of understanding of local power dynamics, local/global relationships, and historical relations (Foale et al. 2013, Clifton and Foale 2017, Fabinyi et al. 2017, Aswani 2019). In other words, the focus of the CTI's managing bodies-- including the Ministry of Marine Affairs in Indonesia, private and public conservation partners--on fisheries production tends to simplify trading roles beyond the harvest level, and in effect, fail to consider the political or social ecology within the social-ecological system (Deswandi 2012, Ferrol-Schulte et al. 2015, Fabinyi et al. 2017). Just as ecological factors affect fishing access to the resource, social attributes including trade networks and market structures shape how benefits are distributed (Crona and

Bodin 2010, Weeratunge et al. 2010, Ferse et al. 2014). These dynamics have important implications for the sustainable and equitable exploitation of marine resources and must be considered by policy to better align with unique institutional settings (Thyresson et al. 2013, Ferse et al. 2014, Nurdin and Grydehoj 2014).

In contexts like Indonesia, where formal regulatory enforcement is weak or nonexistent, informal governance networks called patron-client systems often persist (Basurto et al. 2013, Glaser et al. 2015). A patron-client relationship is characterized as an "unequal (but theoretically nonbinding) relationship between a superior (a patron or leader) and a number of inferiors (clients, retainers, or followers), based on an asymmetric exchange of services" (Pelras 2000, p.16). In these institutions, traders and boat owners-- often embedded in multi-level forms of patronage themselves-- function as bankers to provide credit and social services to lower fisherfolk. As "gatekeepers" of the value chain, patrons influence gear choice, target species, and market pricing, and in turn, social, economic and political decision-making (Miñarro et al. 2016). Though these kinds of hierarchical relationships existed long before the industrial age of fishing, policies attached to the Blue Revolution have amplified and reinforced their effects in Indonesia (Deswandi 2012). Financial assistance in this form is at once considered essential to the flow of fish and livelihood security, while also being a barrier to socio-economic equality and sustainable fishing (Pelras 2000, Ferrol-Schulte et al. 2014, Nurdin and Grydehoj 2014). De-facto trading institutions like these are entry points for understanding the Indonesian fish trade's impact on livelihoods (Radjawali 2012, Hall et al. 2013).

Previous studies have demonstrated the influence of fisheries patron-client systems over trade and livelihood outcomes at the national or regional scale (Pelras 2000,

Nurdin and Grydehoj 2014, Adhuri et al. 2016, Drury O'Neill et al. 2019), but how these processes manifest at the community level is poorly documented. Multi-stranded relationships with economic, political, and social ties demand a more detailed analysis that goes beyond the dichotomies of "fisher" and "trader" and into nested systems and relationships (Pelras 2000, Glaser et al. 2010). While value chain studies have examined the macro-level function of national economies extensively, data-poor fisheries in Indonesia lack empirical evidence of species composition and value attached to this system of trade, particularly at the local level (e.g., Wamukota et al. 2014).

Value chain analysis is one way to understand the distributional effects of trade. A VCA maps the activity of actors participating in production, marketing, sales, and consumption of a product. With the ever-expanding nature of market economies, VCA has become a tool for researchers to examine the characteristics within a given supply chain: profit and cost structures, characteristics of agents, and the flow of goods (Purcell et al. 2017). More recent value chain approaches applied to fisheries have taken social equity into consideration (Jacinto 2004, Loc et al. 2010, Rosales et al. 2017). Although VCAs are designed to assess barriers to livelihood benefits, few move beyond production performance indicators (i.e. income, fish volume, pricing) and actors at the harvest end of the chain like fishers and their immediate buyers (Thyresson et al. 2013, Rosales et al. 2017). A lack of data depicting multi scalar socio-political organization and its relationship to livelihoods in Indonesia limits strategies for enhancing the contribution of fisheries to livelihood security (Tezzo et al. 2020).

To overcome the limitations of conventional value chain approaches and support the well-being of coastal community livelihoods in resource management, social science

scholars have suggested shifting to a perspective that considers the entire value chain from production to consumption and the associated well-being outcomes. This view places fish in the context of a food system (Farmery et al. 2021), which represents "all the elements and activities that relate to the production, processing, distribution, preparation, and consumption of food, and the outputs of these activities, including socio-economic and environmental outcomes" (HLPE 2014). Food systems frames were born from a growing recognition that many of the world's systems are failing to meet standards for equitable and sustainable livelihoods (Freed et al. 2020). As an alternative to paradigms centered around fish production, the "fish as food" framing has the potential to address the complexity of fishing livelihoods by considering a broader range of factors that affect dependence on fish for harvest and trade- defined here as the social, cultural, economic, and nutritional significance that fish, particular fish species, and actors hold for communities in a given fisheries context.

There is ample evidence to suggest that livelihood resilience is a crucial component of sustainable fisheries (Allison and Ellis 2001, Glaser et al. 2015, Cohen et al. 2019). Promoting equity in the value chain first requires an assessment of the vulnerabilities that exist, and the local institutions that mediate it. In an attempt to fill this gap, we aim to better understand the socioeconomic factors that mediate fish catch and distribution in a small Indonesian fishing community governed by patron-client systems using value chain analysis and a "fish as food" framework. The island's social context gives rise to the following questions: i) In what ways does the regional trading system influence livelihood outcomes in the value chain? ii) How does the current structure of trade align with certain fisheries and fishing actors on the island? By situating the role of

particular fishes (pelagic and reef-based) within dynamic social networks, another research aim is to characterize trading dependence in this community. This case study adds to the growing literature documenting the impacts of trade and trade relationships on fisheries, which remains a significant gap in Indonesia's current fisheries policies (Deswandi 2012). In being the first research to connect community-level livelihood outcomes to regional fish trading activities, this study demonstrates the critical need for coordination among formal and informal managing bodies at the national, provincial, and local level in Indonesia. Results are discussed in the context of improving coastal governance strategies to better address uneven livelihood outcomes and the divergent roles various actors play in shaping them.

Methods

Study site and context

The research focuses on Bontosua Island, a small fishing community located in the Spermonde Archipelago (Fig. 2.1). The Spermonde Archipelago in Indonesia extends about 60 km offshore from Makassar in South Sulawesi Province, a popular port for the region's fish trade. As with many other areas in Indonesia, the local coastal population in the region is highly dependent on fisheries resources (Glaeser et al. 2018). Several thousand fishing households are spread throughout the islands and rely on fishing as their primary source of income (Ferse et al. 2012, 2014). Fisheries in the region are characterized by a large variety in gear types and boat sizes, targeting species across both shallow coastal coral reefs and deeper pelagic areas in the open ocean.

The Spermonde Archipelago is believed to have been first inhabited by the nomadic Bajau people in the 16th century (Villiers 1990). The region's islands became

important trading outposts under Dutch occupation in the 17th century and various ethnic groups permanently settled thereafter (Mattulada 1994). Accounts from Bontosua households (Vandenberg et al. 2020) and other scholarly sources (e.g. Knaap and Sutherland 2005) surmise that the people of Bontosua and the surrounding islands fled mainland Makassar in the mid 20th century, seeking political refuge and economic opportunities. Once settled, the once agrarian Makassarese were forced to adapt to their new maritime existence and the social organization it entailed (Knaap and Sutherland 2005).

Similar to other islands in the Spermonde, nearly all adult men on Bontosua are fishermen. A total of 185 households reside on approximately 50,000 square meters, making it one of the smaller islands in the area. Many islanders belong to pelagic fishing crews with 8 to 15 members on a single medium-sized vessel (~20 GT) built for purse seine fishing. A significant proportion of fishers also engage in small-scale fishing of pelagic squid during its season from June to November. The remainder fish for pelagic and reef fish using small boats (<10 GT) and handlines.

Patron-client systems govern access to fisheries and trade in the region (Nurdin and Grydehoj 2014, Glaser et al. 2015). It is theorized that characteristics of patron-client relationships, including asymmetrical exchange of resources, market access, and gear loans, indirectly drive habitat and fisheries degradation in the Spermonde (Ferse et al. 2014, Nurdin and Grydehoj 2014, Glaser et al. 2015). These social networks are thus key features of the value chain to examine when devising strategies to support livelihood stability (Glaser et al. 2010).

Patron-client systems in the Spermonde have been shaped by a centuries-long history of political regimes and maritime trade. The foundation for patronage formed during the pre-colonial era where local rulers required kinship and loyalty to access socioeconomic benefits of the Makassar kingdom (Pelras 2000). With the Dutch colonization of Indonesia during the 18th century, Makassar became a center for international trade (Knaap and Sutherland 2005) and economic terms of patronage developed significance (Meereboer 1998). Post-independence, political instability in the 20th century encouraged the development of informal governance systems to organize trade. Patronage offered protection to those who engaged in the practice; additionally, it enabled them to appeal to urban institutions (Sutherland 2011). Modern patron-client systems have retained some aspects of traditional hierarchies (e.g., social prestige, loyalty) while also being flexible enough to adapt to changing circumstances (Pelras 2000, Deswandi 2012, Ferse et al. 2014).

Data collection and sampling approach

This study sets out to map the dynamics of fish catch and sale originating from the island of Bontosua. We conducted survey-based fieldwork that tracked fish volumes, prices, links, and relationships from December 2019 to February 2020. The hour-long surveys were designed in the local language of Makassarese and included both open-ended and closed responses from both fishers and traders. Questions were tested twice with a subset of respondents (in Makassarese) and modified based on the actor types and dynamics in each fishery. The final survey captured value chain data related to: i) catch, using local fish guides developed with Bontosua islanders prior to the survey; ii) sale, including which actors the fish are bought and sold from, prices, and places, iii) revenue,

and iv) seller/buyer relationships. Since some of the qualitative survey questions did not distinguish between multiple roles, only single-role respondents (e.g. independent squid fishers who did not also serve as crew members) were considered in the final analyses for buyer/seller relationships. Each respondent was asked to consider their catch and trade for a typical day during the calm and windy season, with the calm season (June to November) representing a period of high catches, and the windy season (December to April) yielding fewer catches.

The proportion of each fisher type on the island was not known, however insight during key informant interviews with community leaders determined that fishing groups tended to reside on different sides of the island. Therefore, to obtain a representative sample of the island's fishers, we employed a stratified random sampling design, interviewing approximately 13 fishers in each directional quadrant: north, south, east, and west. Semi-structured surveys were administered to the head fisher of each household, in total representing nearly one-third (52 fishers) of the 182 households located on the island.

All traders (N=9) residing on Bontosua took part in the surveys; this way, total trade volume exiting the island could be approximated. The next step was to identify actors "downstream" (i.e. the off-island points of trade in the value chain). Here, a snowball sampling approach was used to identify the remaining trading actors connecting the value chain that did not reside on the island (e.g. middlemen). In contexts where the composition of actors is unknown by the researchers in advance, this method can ensure that the appropriate contacts are eventually identified (Biernacki and Waldorf 1981). The data collection period reached its completion with end traders in the Makassar markets,

the last trading junction for Bontosua fish before they reach local consumers throughout Makassar. In all, this approach yielded information from 23 traders on- and off-island.

Price and volume of fish species were generally given in formats akin to their sale, such as baskets, individual fish, and boxes. Additional interviews in March and December 2020 sought to standardize these size ratios to kilograms for analysis, and triangulate market prices provided during the survey interviews. Small baskets were estimated to contain approximately 5 kg of fish, while large baskets and boxes were estimated to contain 15 kg of fish.

Data analysis

Descriptive analyses with average catch volume, prices, expenses, and income were accomplished using SPSS Version 26. The data sample includes a significant portion with fishers who belong to boats with multiple fishers, so to avoid overestimation, only the fish catch reported by the boat captain or boat owner of each vessel was reported in the analyses. Additionally, Bontosua fishers only go out to sea when the weather is permissible, while Makassar traders handle fish every day. Catch per unit effort was equivalent to the amount caught on each boat for each gear type. To convert catch amounts to trade, the total amount caught was divided by the average number of days each fisher goes out to sea in the calm or windy season.

Data on actor connections, catch volume, and market value for the fisheries informed value chain maps. A different map was created for each fishery and season using R statistical software (version 3.5.1; R Core Team 2018) and the ‘netmeta’ package (Rucker et al. 2018). Actors in the value chain were represented by nodes. Total value and volume between each node were represented with proportional arrows as the fish

catch moves from the beginning to the end of the chain. The size of each node indicated the degree of connectedness (i.e. number of links) between each actor and the rest of the value chain.

Value represents revenue, calculated using the following equations for fishers (Eq.1) and traders (Eq.2):

$R_f = ((q_p * s_p) * T_f * P_s)$ (Eq.1)

Where R_f is fisher revenue on an average day during the calm or windy season, q_p is quantity of fish caught in kg on an average day during the calm or windy season, s_p is selling price of fish in Rp/kg on an average day during the calm or windy season, T_f = proportion of time spent fishing on an average day during the calm or windy season, P_s = profit share.

$R_t = ((q_p * s_p) - (q_p * b_p)) * P_s$ (Eq.2)

Where R_t is trader revenue on an average day during the calm or windy season, b_p is the buying price of fish in Rp/kg on an average day during the calm or windy season.

Profit share is the proportion of the selling price that each fisher or trader receives from the sale. Profit sharing is an extension of the patron-client system, existing as the primary line of credit for fishers and traders for whom formal banking systems are inaccessible (Ferrol-Schulte et al. 2014). Patrons extend credit to their clients to meet their everyday needs, or to purchase gear and boats. In exchange, the client is obliged to sell their fish to their patron. The patron then takes a portion of the profits from the fish sale. This setup can confer stability to both the patron and client by ensuring the relationship continues, and additional financial advantage to the patron by granting power to set the price and reduce transparency in the buyback process compared to a

conventional loan (Ferse et al. 2014, Ferrol-Schulte et al. 2014). Since payment amounts and frequency depends on debt status and relationship with each buyer and seller, the exact profit sharing amount for each respondent in the study could not be obtained. Each respondent was instead asked to report the proportion of value they retain in a standard transaction. Although this method potentially reduces the accuracy of revenue estimates, inquiring about individual debt was not feasible. The intent instead was to gain a general understanding of trading patterns across different links of the value chain.

Quantitative analyses were undertaken in SPSS Version 26. Differences in revenue among actor groups were explored with a one-way analysis of variance (ANOVA) and Tukey post-hoc tests. We used the Kruskal-Wallis test with Bonferroni correction, followed by Mann Whitney post-hoc tests, for catch and trade volume across actors because the data were non-parametric. Finally, Welch's ANOVA and Games-Howell post-hoc tests (nonparametric) were applied to evaluate differences in market price across fish groups (small pelagic, large pelagic, reef, and pelagic squid).

Results

Actor titles and responsibilities

Fishing

Survey sampling and key informant interviews identified three main fishing formats on Bontosua: medium-sized vessels (~20 GT) (hereafter called crew boats) which targeted pelagic fish; independent fishing for pelagic or reef fish; and independent squid fishing in the nearshore pelagic areas. All independent fishers- referring to independent pelagic/reef fishers and squid fishers- were considered small-scale in Indonesia because they operated vessels under 10 GT in size.

Crew-based fishing was the most popular fishing format on Bontosua, representing 180 actors on 22 boats. This accounted for 76% of the island's fishing workforce (*N*=237) and 77% of the fishers surveyed (*N*=53). Within each boat there were three categories of actors: owner, (*N*=6); captain (*N*=7); and crew members (*N*=31). Two of the actors interviewed held both boat owner and captain positions. The average size of a boat crew was 13 members (± 2.08). Boat captains handled the daily affairs of the boat, including trade, a majority of the cash lending to crew, and fishing management at sea. This left boat owners with the responsibility of fronting all expenses- fixed and variable- required to fish. All crew boats targeted pelagic fish with 200 to 300-meter purse seine nets.

Half of surveyed crew members (51%) and a majority of independent fishers (80%) also operated squid fishing boats during the squid season from June through November. Squid fishing was a role taken on by 43% of all fishers on the island (*N*=237) and over half of all respondents (29 out of 53 fishers surveyed). The operation involved some gear exclusive to squid fishing, including specific bait hooks (*canda* or *doang-doang*), but much of the physical capital required was interchangeable with other independent fishers. Independent pelagic and reef fishing was the least popular fishing approach on the island at 8% (*N*=18) of the workforce and 8% of the respondents surveyed (*N*=5). Independent fishing consists of one-man crews employing small-scale handline and longline techniques in reef and nearshore pelagic areas.

All fishers were engaged in fishing full-time; however, the extent of their involvement was seasonally determined. In the calm season from April to November, fishermen went out to sea an average of 20 (± 5) days a month. Most fishing did not

occur during the week of a full moon based on the belief that light interferes with fishing activities. Fishers reported less frequent trips during the windy season (November to April) (13 ± 6 days) as strong winds brought adverse weather conditions to the surrounding reef and pelagic areas.

Trading

Surveys revealed a systematic regional trading system from point of capture to end sale in the port city of Makassar. The morning following each fishing trip, Bontosua crew boats traded their catch on-island to the next link in the chain: crew collectors (*N*=3). Crew collectors on Bontosua sourced exclusively from the island's fishing crews. All independent fishers sold the entirety of their catch to on-island independent collectors (*N*=5). Both types of collectors reported selling their catch to traders off-island: auctioneers at the landing site in Makassar (*N*=4), or less commonly, to auction traders (*N*=2). Auctioneers had several options for buyers, including consumers in Makassar markets, auction traders, and end traders in Makassar markets (*N*=9). Auction traders sourced exclusively from auctioneers and sold to a combination of end traders and consumers in Makassar markets.

Fish composition in harvest and trade

Harvest

Fishers on Bontosua reported catch amounts and values for 20 species: 16 pelagic-associated and 4 reef-associated species. This analysis details the 12 species that were mentioned by 5 or more fishers. The final list spans 4 fish types that are biologically and spatially distinct: small pelagic fish (*N*=5) (classified as "small" if their listed common length was 30 cm or less on FishBase (FAO 2004, Rountos 2016, Braham and

Corten 2015, Froese and Pauly 2021), large pelagic fish (*N*=3), pelagic squid (*N*=1), and reef fish (*N*=3) (Table 2.1). Catch and trade results will discuss inter-group variability among the species analyzed.

Bontosua catch was dominated by pelagic species, with pelagic finfish representing 78% by volume and 77% of the value gained by Bontosua fishers in the calm season and 88% of the volume and 90% of the value in the windy season. Small pelagic species had the largest share of volume and value of any fish type across both seasons (Fig. 2.2). Total harvest was dominated by crew boats which caught 78% of all fish by weight on the island in the calm season and 82% in the windy season and retained 77% of the value in the calm and 85% of the value in the windy season accrued by on-island fishers. Small-scale capture was compositionally similar to crews with the exception of large pelagic species, which were not part of the independent fishing portfolio, and squid, which crew boats did not catch (Fig. 2.2). Purse seines had a higher average catch per unit effort across both seasons (calm, X^2=10.687, *p*=0.005; windy, X^2=10.705, *p*=0.005) when compared to independent fishers (pelagic/reef, *P*= 0.016; squid fishers, *p*=0.005). This trend continued with higher catch per capita compared to independent pelagic/reef (*p*=0.055) and squid fishers (*p*=0.03) in the calm season (X^2(2) = 7.165, *p*=0.028), and a nonsignificant pattern in the windy season (X^2(2)= 5.394, *p*=0.067). No significant difference was found between independent and squid boats in per boat or per capita catch (X^2(2)= 6.345, *p*> 0.05). There was a significant decline in average catch amount per boat for all boat types (crew boats, t(3)=10.549, *p*=0.002; independent pelagic/reef boats, t(4)=3.925, *p*=0.017; squid boats, t(3)=4.119, *p*=0.026) in the windy season.

The pelagic squid fishery played a smaller role in the island's harvest but a major role in small-scale fishing. In the calm season, squid fishers caught 20% of the total fish volume and retained 19% of the value in the Bontosua fishing portfolio, ranking squid (*cumi teropong*) third for the island's harvest in that season (Fig. 2.2). Squid represented 84% of the island's small-scale fish harvest in the calm season and 73% in the windy season respectively, and 87% of the value retained by independent fishers in the calm season and 80% in the windy season. Small pelagic and reef fish each made up around 7% of the small-scale fish catch by volume in the calm season and 15% in the windy season. At 2% and 3% of the total catch by volume in the calm and windy seasons respectively and 2% of the catch value, reef fish were the least represented fish type in Bontosua catch. Only 2 fishers in the survey reported catching species on the reef.

Trade

Marketplaces connected to Bontosua trade were oriented towards crew-based fisheries landings. The top three most popular species traded by weight were the consistent across crew boats, on-island, and off-island traders: small pelagic species *Rastrelliger kanagurta* (English name "long-jawed mackerel"; Makassarese name "banyara") and *Selar boops* (English name "oxeye scad"; Makassarese name "katombo"), and *Katsuwonus pelamus* (English name "skipjack tuna"; local name "cakalang"), a large pelagic species. Pelagic fish represented 89% of the volume and 83% of value in the trading system overall, followed by squid and then reef fish (Fig. 2.3). Small pelagic was the top fish type traded by volume during the calm (70%) and windy (75%) seasons. Species in this category accounted for over half of the total traded volume for nearly every link in the chain across both seasons, and a slightly greater dominance during the

windy season (Fig. 2.4). Independent fishers and their collectors on Bontosua were exceptions because squid was the dominant catch. The share of small pelagic fish in the trading portfolio was highest at the end of the chain; over 80% of the fish offered by end traders in Makassar during the calm and windy seasons were small pelagic species (Fig. 2.4).

Pelagic squid (*Loligo spp*.; local name "cumi teropong") was the third-most popular species offered by Bontosua fishers overall, and the only species exhibiting an export trade pathway. 34% of squid volume in the calm season and 41% in the windy season sold by on-island traders went directly to exporters instead of the regional marketplace. Squid was the least represented catch in the Makassar marketplace at 4% of end trader volume in the calm and windy seasons (Fig. 2.4).

With only 2 independent fishers in the surveys harvesting on reefs, and around 8% of the island's fishers identifying as independent pelagic/reef (*N*=18), exchange of reef fish from Bontosua was limited. Reef fish represented 3% of the catch leaving Bontosua in the calm season, and 1% in the windy season. In the Makassar marketplace, a similar pattern arose: end traders sold fish consisting of 8% reef-derived species in the calm season, and 7% in the windy season (Fig. 2.4).

Trade relationships in the patron-client system

Surveys and key informant interviews with Bontosua fishers and traders described a hierarchical, debt-based structure to regional trade. The patron-client system was common from Bontosua to the Makassar landing site; 87% of fishers (*N*=53) and 42% of traders (*N*=24), including 5 out of 9 on-island, were involved in credit relationships. The status of patron (lender) or client (debtor) was determined based on whether each

respondent was on the giving or receiving end of a) debt to a buyer and/or b) profit sharing. These arrangements are explored in the following sections.

Profit sharing

Profit sharing was one of the primary means by which actors in the chain settled debt. In a profit share, patrons lend money to clients in exchange for a percentage of the client's sale. In this island setting, profit sharing was enacted in part because of the high capital requirements of crew boats on Bontosua, all of which (N=8) took part in the profit-sharing scheme. At an average cost of nearly 180 million Rp (± 63 million), crew boats were the largest reported expenses by any fisher or trader. This is compared with 4 million Rp (± 3 million) for small-scale fishing boats. Crew boats typically accrue higher fuel costs from traveling up to 20 km from land to target schools of pelagic fish. Fishers in the key informant interviews explained that owners and captains were bridging actors, acting not only as clients borrowing from their collector and auctioneer buyers, but as patrons to their crew. Most crew members borrowed money from their boat captain and/or boat owner for daily needs in the windy season or to purchase equipment for their seasonal squid fishing operations. Creating debt to the boat was one of the primary means by which boat owners and captains maintained the loyalty of their crew.

Profit sharing steps from crew boats to the landing site in Makassar applied to all respondents attached to crew-based fishing trade. In the surveys, crew collectors reported taking each desired fish species from the boat captains on Bontosua to the landing site in Makassar. At the landing site, auctioneers appraised the catch for 5-7% of the sale profit. After the collector received their cut of 8-10%, the remaining profit was then transferred to the crew boat for distribution. There, the boat owner would take 50%, the captain

would take 15%, and each crew member would split the remaining value (approximately 2-4% per fisher, depending on the size of the crew) (Fig. 2.5). During informal discussions a number of fishers indicated that these values were conservative because patrons may take a greater proportion of profits if they deem it appropriate for the debt owed.

Governance of sale

The status of patron or client in selling relations dictated trading, governance, and economic power in the Bontosua-Makassar value chain. 29% (*N*=78) of seller respondents were classified as clients based on their credit-based relationships with at least one buyer. Of this, most were independent fishermen (including squid, pelagic, and reef) (9 out of 23 clients) and crew members (7 out of 23 clients) in debt to independent/crew collectors, while the remaining were independent/crew collectors (7 out of 23 clients) who borrowed from their auctioneer. 25% of buyers (*N*=24) were classified as patrons based on their credit-based relationships with at least one seller. This included all auctioneers (*N*=4) and two independent collectors.

Flexibility in buyer/seller choice was a key feature of patron-client relationships. 95% of client sellers (*N*=24) did not feel they could replace their buyer and/or sell to another buyer, compared to 25% of non-client sellers (*N*=56). A primary reason given by non-client sellers for their obligation was family connections between Bontosua fishers and on-island traders (15 out of 16 responses). One off-island trader stayed with his client because of the debt he was owed. All patrons (*N*=6) felt free to replace their buyer or sell to another buyer if they wished.

Position in the value chain and patron-client status also played a role in autonomy over buying/selling price. 83% of patrons (*N*=6) reported having sole control over the price of the fish they buy, compared to 33% of non-patron buyers (*N*=18). On the selling end, only 8% of clients (*N*=21) reported having sole control over the price of fish, compared to a vast majority of non-client sellers (44 out of 56 sellers). According to responses for "who determines the buying/selling price of your fish?", auctioneers and boat captains had the most autonomy over sale price. 39% of fisher responses (*N*=53) suggested that price was set by the boat captain, while 40% of trader responses (*N*=48) and 33% of all responses (*N*=101), noted the auctioneer. All auctioneers believed that they had sole control over both the buying and selling prices of fish. A majority (19 out of 24 interviewed) of all traders (*N*=24) believed they jointly or solely decided on buying and/or selling prices of fish. Bargaining power was further illustrated by the exclusive membership of actors in information exchange. Of all the fishing and trading actors prompted, only auction traders and auctioneers (*N*=5) were members of trading organizations.

Trading structure of the patron-client system

Trading network capacity

The value chain exhibited an hourglass shape (Fig. 2.6), whereby a small number of actors in the middle of the chain channeled fish from much a much larger number of fishers and collectors at the Makassar landing site. On a typical day of trade, active fishers on the island (*N*=120) sold to 9 collectors on Bontosua. All collectors sourced their catch from Bontosua actors and sold to 1 Makassar auctioneer. Records of the auctioneer names provided by collectors identified 5 auctioneers and 5 auction traders

involved in the Bontosua-Makassar chain. The pool of buyers expanded once the catch reached Makassar: receiving catch at the Makassar port from Bontosua and other islands in the region, auctioneers purchased from 18 collectors and sold to 35 end traders and an unknown number of consumers. Similarly, auction traders in Makassar bought from the available auctioneers and sold to around 20 consumers. End traders sourced from a combination of auction traders and auctioneers, before selling the final product to approximately 60 consumers.

Volume capture by actors

Auctioneers exchanged the most volume out of any actor group- 4 traders handled 46% during the calm season, and 58% during the windy season (Fig. 2.7). Each auctioneer handled more volume on average compared to every other fishing or trading role in both the calm (Z=-2.449, p=0.014) and windy (Z=-2.449, p=0.014) seasons with the exception of crew collectors (Calm, p=1.00; Windy, p=0.077). During the calm season, 29% of daily fish volume passed through 3 crew collectors on Bontosua. This proportion dropped to 9% during the windy season when crew catches were low. 5 independent collectors on Bontosua, sourcing from independent fishermen, handled 6% of the volume during the calm season and 3% during the windy season. Lastly, 4 Bontosua crew boats harvested and traded 9% of the total volume in the value chain during the calm and windy seasons. 28 squid fishers from Bontosua traded a total of 2% of the volume during both seasons- 19% and 11% in the squid fishery alone, for the calm and windy seasons respectively. Independent fishers from Bontosua caught less than 1% of the total fish volume in the value chain across both seasons, and 10% in the calm season (14% in the windy) when only considering the reef fishery. Leading to the

Makassar landing site, 8% of the total traded volume in the calm season passed through the independent fisher pathway, while 38% was crew-based catch (Fig. 2.7).

Value capture by actors

In the calm season, total value retention, or the total proportion of sales for all species that were kept by each actor group in the value chain, was highest for crew collectors (3 individuals retaining 23%), boat owners (4 individuals retaining 18%), and auctioneers (4 individuals retaining 10%) (Fig. 2.7). The value accruing to crew members (26% for 43 fishers), independent pelagic/reef fishers (1% for 5 fishers), and independent squid fishers (11% for 28 fishers) was lowest. The Kruskal-Wallis test showed there were significant differences in revenue, calculated as the average value retained by individual actors, across actor types in both the calm ($X^2(9)=51.912$, $p<0.001$) and windy ($X^2(9)=50.925$, $p<0.001$) seasons (Fig. 2.8). Based on the post hoc pairwise comparisons, differences in the calm season can be attributed to patrons involved in crew-based trade (crew collectors, boat owners, auctioneers) with higher revenues than clients (crew members, independent pelagic/reef fisher, independent squid fisher) and end traders. Crew collectors and boat owners earned more revenue than all other actors except auctioneers. Up until their collection in Makassar, the independent fisher pathway on Bontosua generated 18% of the total value in the chain, while the crew-based pathway captured 56% (Fig. 2.7). In the windy season, value retention remained high for boat owners (19%), while auctioneers played a larger role at 20% the total value. Additionally, end traders became more important players, with 8 capturing 22% of the value compared to 5% in the calm season. Value retention for crew collectors, squid fishers, and independent collectors declined in the windy season, while independent fishers increased

slightly to 1.5%. Auctioneers and end traders maintained higher revenues over clients (crew members and independent squid fishers) in the windy season (Fig. 2.8).

Desire to change positions

When asked "would you want to switch to a different fishing/trading role?", a vast majority of fishers (43 out of 53 interviewed) responded with "yes". All but 4 responses were crew members or independent fishers desiring a boat captain or boat owner position. Most of the fishers (31 out of 43 interviewed) who wanted to change desired more income. Traders were largely satisfied with their roles; 17% wanted to become a boat owner for greater income (N=24), while one independent collector wanted to become a crew collector for the same reason.

Discussion

While defining features of patron-client relationships have been examined in Indonesia and elsewhere (Ferrol-Schulte et al. 2014, Ferse et al. 2014, Wamukota et al. 2014), few studies have connected this governance system to fish flows and community-level outcomes. Value chain analysis is a useful tool for management planning in data-poor fisheries because it can identify socially meaningful dependencies between actors and marine resources. To our knowledge, this study is the first to document the trade dynamics of a regional value chain from the perspective of a single fishing community. By tracking nested relationships, resource dependence, and socio-economic outcomes at the local level, we show that patron-client relationships mediate catch and trade on and off-island. On the island of study, a debt repayment system known as profit sharing organizes pelagic crews- the dominant form of fishing on the island- and their trading partners. This coupled dependence on fishing form and the trading system it connects, not

only affects the immediate economic and social outcomes from the value chain, but also may limit the practicability of livelihood flexibility and sustainable fishing practices. Since binding social and economic ties extend throughout the value chain, any reform efforts should involve cross-sectoral cooperation between formal management at the regional and local level, fishing and trading actors at each link in the chain, and private and public conservation partners.

Patron-client relationships

The self-governing function of patron-client relationships and their unequal livelihood outcomes have major implications for social and ecological sustainability (Basurto et al. 2013). Our study has provided additional evidence for the "captive value chain" theory observed by Purcell and colleagues (2017), in which suppliers are dependent upon larger, more connected buyers for financial support and sales (Gereffi et al. 2005). Patrons are central actors in the Bontosua-Makassar value chain, controlling the flow of fish volume, prices, and market information.

Nearly all (86%) respondents we sampled engaged in direct lending and/or profit sharing, providing clear evidence that the patron-client system is extensive and deeply embedded throughout the Bontosua-Makassar fisheries value chain. Based on their lending activity, four patron categories were identified: boat owners (on-island), boat captains (on-island), collectors (on-island), and auctioneers (off-island). As with other patron-client systems in Indonesia (e.g. Ferse et al. 2014) debt and profit sharing influence unequal profit distribution. All types of patrons were found to have higher revenues over the remaining fishers in the chain. This conclusion is similar to the one drawn by Wamukota and colleagues (2014) in Kenya which showed that traders had

higher income levels than fishers. However, in our study, the type of fisher and their status as a patron or client mattered greatly for revenue. Fishing clients who owe debt to a seller, including crew members and independent fishers, occupied the lowest revenue grouping. In the case of fishing crews, profit sharing locked each crew member into receiving on average 3% of the first sale, compared to 43% for each boat owner and 13% for every boat captain. These values are nearly identical to the profit-sharing breakdown reported in a value chain analysis of Philippine fisheries under patron-client governance (Rosales et al. 2017), suggesting it might be a regional norm.

In addition to lending, other forms of social capital may contribute to the relatively higher returns achieved by patrons. Patrons in this value chain enjoyed greater control over buying and selling price and flexibility in trading arrangements. All patrons and most other non-client sellers reported determining the prices of fish they exchanged either jointly or solely, while essentially no clients had no influence over sale price. Inflexibility accompanied a lack of bargaining power among clients: because of their debt, most could not replace their buyer or sell to anyone else. Previous studies have found that a lack of bargaining power and flexibility are often indicators of economic vulnerability because they restrict adaptive capacity (MacFadyen and Corcoran 2002, Loc et al. 2010, Drury O'Neill et al. 2019). For example, a case study in the Philippines demonstrated that while patron-client systems can shield fishers from short-term economic hardship through gear and loan provisioning, these coping mechanisms can inhibit long-term investments in sustainability and alternative livelihoods (Drury O'Neill et al. 2019). Unchecked bargaining power by patrons has been linked to overexploitation

of target species (Kaplinsky 2000, Ferse et al. 2014), and often prevents fishers from engaging in collective action for fishing rights and market information (Johnson 2010).

Another element that is facilitating power asymmetries between actors is the value chain's distinct hourglass shape. The number of actors reduces significantly at the middle of the chain, with 120 fishers on Bontosua supplying just 5 auctioneers in Makassar. This pattern is consistent with other fishery value chains in the region (Purcell et al. 2017, Sadovy de Mitcheson et al. 2018). A narrowing of buyers at Makassar ports means that auctioneers hold a central position in the value chain, trading large fish volumes, accruing a majority of the value available, and establishing the largest number of connections with fishers and traders. Since nearly all catch from fishermen on Bontosua (reef, pelagic finfish, pelagic squid) ended up in the hands of auctioneers in Makassar, they act as the gatekeepers of regional trade. The wide pool of buyers and sellers available to auctioneers could also help explain why they experienced greater revenue stability from the calm to the windy season compared to other actors. Borrowing is particularly important during the windy season as fishers cope during low catch periods (MacFadyen and Corcoran 2002). Auctioneers, possessing high capital and diverse market connections, were best positioned to provide support through lending.

Dominance of pelagic crew-based trade

Our findings show that pelagic crew-based trade mediates the movement of catch from island to market. Most of the volume and value in the supply chain was handled by crew collectors and auctioneers sourcing from pelagic fishing crews. Small pelagic fish were the most common fish caught and traded both on and off-island, while coral reef fish made up only a small fraction. The dominance of small pelagic fish in island catch

was expected given that a vast majority of fishers on the island were employed in crew-based fishing and that crew boats were found to have the highest catch efficiency. On the other hand, small-scale fisheries catch was diluted in the total catch: independent fishers harvested less popular fish types like reef fish, and the pathway from catch to market involving small-scale fishers captured only a fraction of value and volume available in the value chain. The exception to this was squid, since a majority of crew members also operated small-scale squid fishing boats during parts of the year. To explain the high employment in squid fishing, conversations with fishers and traders determined that most of the island's squid boats were financed by loans from boat captains and owners. As documented in the Spermonde (Deswandi 2012, Adhuri et al. 2016) and Kenya (Crona and Bodin 2010), gear ownership networks marked by a few lending actors often determine harvest patterns, restricting flexibility and diversification in harvest.

The strong orientation of Bontosua catch and trade towards pelagic crew-based fishing supports the concept of a fishing "lock-in", applied previously to the Spermonde region (Deswandi 2012). A lock-in occurs when repetitive interactions between actors result in a dominance of a particular mode of action. The drivers and consequences for dependence on fishing at a regional level include resistance to switching technologies or targeting new species (Deswandi 2012, Drury O'Neill et al. 2019). Our results support this theory at the community level, with noticeable effects on the composition of island professions, harvest, and trade. Specializing in pelagic crew-based fishing on Bontosua means engaging in long chains of indebtedness where financial protection is strong, but autonomy and alternatives are scarce. Such a dependence may provision vital short-term support at the expense of social and ecological resilience within the fishery (Drury

O'Neill et al. 2019). By structuring catch and trade around pelagic crews, regional markets also risk the long-term sustainability of small pelagic fish stocks; in fact, overexploitation of pelagic species has already occurred throughout much of Indonesia (Ferrol-Schulte et al. 2015).

This initial assessment provides an overview of catch and trade composition by species in the Bontosua-Makassar value chain. There are limitations to using estimates of seasonal time frames to guide responses. Since the surveys prompted fisher and trader respondents to consider all species and amounts caught and traded on a "typical" day during the calm and windy seasons, value and volume are possibly overestimated. The estimates provided here are primarily intended to provide relative comparisons, and therefore caution should be used if interpreted as absolute figures. Time series data on catches and trade are needed to triangulate the findings presented here and used by managers to track fluctuation in supply and demand.

Governance and management implications

Since patron lending appears to be the primary way capital accumulates in the value chain, alternative credit could offer one avenue for more equitable returns. It is widely believed that microcredit and savings schemes can improve value chain equity by reducing dependence on patrons (Loc et al. 2010). However, there are a number of constraints to achieving a structural change in the value chain. Our context-specific analysis revealed nested hierarchies where some actors function as both patrons and clients, and where entire value chains are involved in debt repayment, suggesting that these relationships are deeply embedded (Crona et al. 2010, Nurdin and Grydehoj 2014). We have also shown that trust and family are major components of trading relationships

on the island of study. Ignoring these cultural and social factors governing trade at the local level can lead to oversights in management and assumptions that adaptations will be readily adopted when in reality that may be impossible given the current fishing structure (Adhuri et al. 2016, O'Neill et al. 2019). For instance, microcredit schemes provided by formal institutions are less likely to be adopted by regional actors because they cannot match the flexibility and familiarity/loyalty of informal lending regimes (Loc et al. 2010).

Having flexibility in one's livelihood strategies is necessary to improve adaptive capacity and adjust to the various stressors existing in the fish trade (Cinner et al. 2018, Bene et al. 2010). Path dependence may reduce the ability of resource users to navigate change, like seasonal variability and long-term shifts in fish stocks (Drury O'Neill et al. 2019). Here we observe several characteristics supporting path dependence for Bontosua's catch and trade: i) highly predictable exchanges, ii) centrality of a few actors, and iii) a "lock-in" with crew-based fishing. This structure appears to be enabled and maintained by profit sharing, wherein many actors are dependent on their sellers for loans. While this study did not investigate the cause-and-effect relationship of species demand, other research set in the Spermonde and small-scale African fisheries has suggested that demand for particular species originates from lenders (e.g. Crona and Bodin 2010, Schwerdtner Mañez and Ferse 2010, Thyresson et al. 2013, Adhuri et al. 2016). One major consequence of lending dependence is a structural inability of fishers and traders to switch out of their current mode of fishing, which can contribute to overfishing and to economic disparities (Schwerdtner Mañez and Ferse 2010). The Bontosua-Makassar trading system exhibits a strong dependence on highly migratory

pelagic species, which despite their importance in this local-regional context have received limited attention from management and conservation in Indonesia compared to coral reefs (Clifton and Foale 2017). Given the existence of other island communities in the Spermonde such as the one depicted on Bontosua (e.g. Glaser et al. 2015) which are governed by dynamic and complex interactions between people and fish resources, interventions in the region should not assume a uniform dependence on any particular actor or fish, but must instead be attuned to the existing trading system of local communities.

Actors who possess bridging, bonding, and linking ties—the major components of social capital-- offer potential for coordinating efforts at the island and inter-island level, making their cooperation paramount in management efforts (Barnes-Mauthe et al. 2014). Auctioneers in our study are considered "opinion leaders" for holding central positions in both the knowledge and lending networks (Crona and Bodin 2010). Additionally, they offer bridging ties between fishing and trading actors on individual islands and link them to the wider market (Ferse et al. 2014, Adhuri et al. 2016). Based on the nature of their centrality, auctioneers are highly influential actors with the capacity to build trust in governance processes. Patrons who are fishers themselves (i.e. boat owners/captains) can also have a profound influence over the structure of fishing and trade (Deswandi 2012). In the case of Bontosua, most fishers aspired to become boat owners because of their higher income status and believed that boat captains had most of the bargaining power over fish price. In addition to bridging crew members and small-scale traders, boat owners/captains also bond multiple types of fishers through debt,

contributing to social cohesion and offering opportunities for knowledge transfer within the community (Crona and Bodin 2010, Deswandi 2012).

In summary, this paper has utilized a value chain case study analysis to reveal key socioeconomic factors affecting fisheries management and governance in the highly localized yet widespread patron-client fish trading systems of Indonesia. Improving resource governance has become a key focus for fisheries management, however, formal regimes in the Spermonde Archipelago have struggled to translate their goals into practice (Radjawali 2012, Ferrol-Schulte et al. 2015, Clifton and Foale 2017). Current strategies for fisheries management in the Spermonde do not consider the impacts of trade on capture fisheries, nor do they sufficiently acknowledge the importance of developing inclusive management and conservation strategies for pelagic spaces. Rather than limiting forms of management to fishing effort or gear restrictions and marine protected areas, for transformations to occur, actors and their interactions with one another must be prioritized (Clifton and Foale 2017, Drury O'Neill et al. 2019). Patron-client systems offer a level of social and economic security that would be difficult to replicate with other forms of lending in the Spermonde (Adhuri et al. 2016). Additionally, patrons are the gatekeepers of information that they can transmit across bridging ties. However, the long-term sustainability of patron-client relationships is questionable because they rely on asymmetrical exchanges (Minarro et al. 2016, Drury O'Neill et al. 2019). In our study, Bontosua fishers face many of the most commonly discussed indicators of livelihood vulnerability, including: seasonal fluctuations in natural resources, variable access to markets, and high dependence on patron-client relationships (MacFadyen and Corcoran 2002). Systems with these characteristics tend to respond

poorly to conventional top-down management strategies to improve fish stocks, food security, and fish-based livelihoods (Glaser et al. 2010). Our results instead support the idea that in order for fisheries reform to be effective, managers must strike a balance between working with the hierarchical socioeconomic structures in place within the trading system while also incorporating the perspectives of fishers and traders. Management that only considers fish production and general fisher or trader categories at the regional level are likely to miss the localized nuance that defines informal governance systems like the one featured in our study. Management and conservation partners would benefit from a greater awareness of organizing factors and of the granularity of social arrangements provided in this study.

Acknowledgments

We wish to thank our other enumerators on the project (Arham Icwardanhi and Muhammad Zulkifli R). A major gratitude is owed to Universitas Hasanuddin for hosting our scholarship. This work was supported by a joint grant from MARS Symbioscience and the University of Rhode Island. A research permit to NR for this research was issued by the Indonesian Ministry of Research. The views expressed herein are those of the authors and do not necessarily reflect the views of their agencies.

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Tables

Table 2.1. Fish species included in the value chain analysis, stratified by fish type.

Fish type	***Fish species***		
	Scientific name	Common name (English)	Common name (Makassarese)*
Small pelagic fish	*Rastrelliger kanagurta*	Long-jawed mackerel	*Banyara*
	Selar boops	Oxeye scad	*Katombo*
	Sardinella gibbosa	Goldstripe sardine	*Tembang*
	Decapterus macarellus	Mackerel scad	*Layang*
	Karalla dussumieri	Dussumier's ponyfish	*Bete-bete*
Large pelagic fish	*Sphyraena qenie/jello*	Pickhandle/blackfin barracuda	*Asa-asa*
	Katsuwonus pelamus	Skipjack tuna	*Cakalang*
	Scomberomorus commerson	Spanish mackerel	*Tenggiri*
Reef fish	*Siganus lineatus*	Golden lined spinefoot	*Baronang*
	Balistapas undulatus	Orange-lined triggerfish	*Papakulu*
	Sepioteuthis lessiona	Bigfin reef squid	*Cumi bantolang*
Pelagic squid	*Loligo spp.*	Mixed pelagic squid	*Cumi teropong*

Makassarese is the local language spoken in Makassar and on Bontosua.

Figures

Fig. 2.1. Map of the study region of Sulawesi and the Spermonde Islands (shown by the arrow) with the study site of Bontosua Island labeled. Much of the fish caught by Spermonde islanders is traded in the city of Makassar, a regional fishing port.

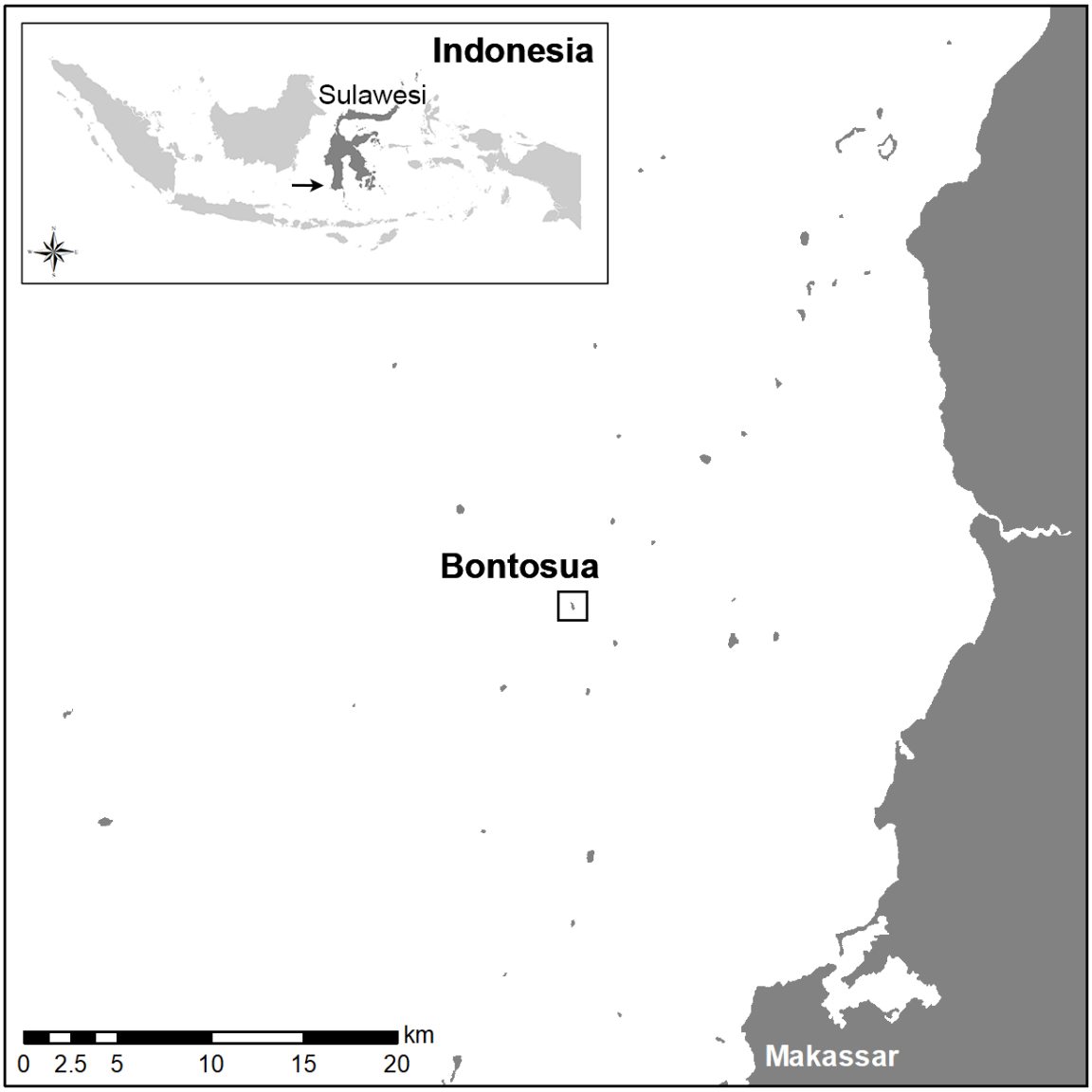


Fig. 2.2. Catch composition of fishing actors as a percentage of total catch volume (kg) during the calm and windy seasons.

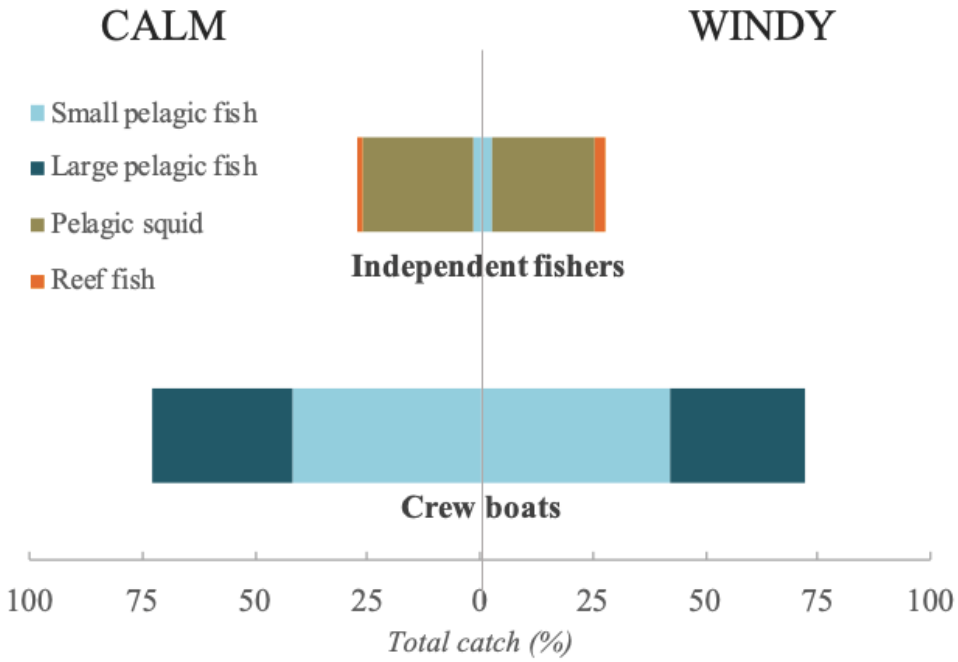
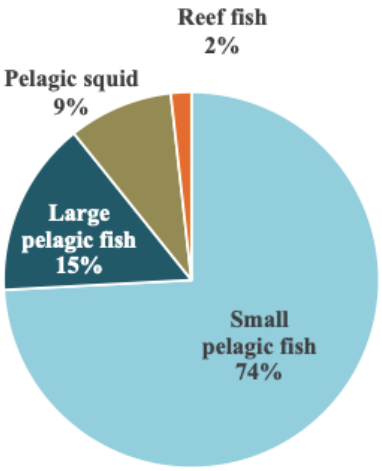


Fig. 2.3. Proportion of total traded (a) volume and (b) value of fish types, combined across the calm and windy season.

(a) Volume



(b) Value

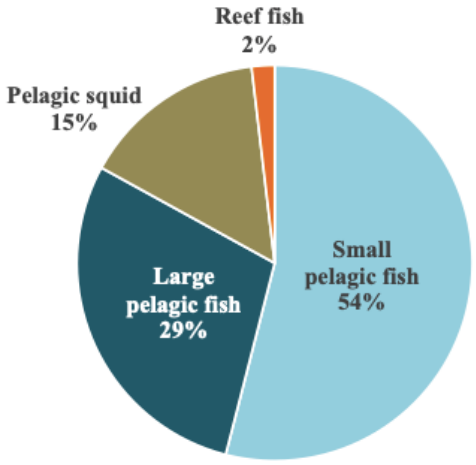
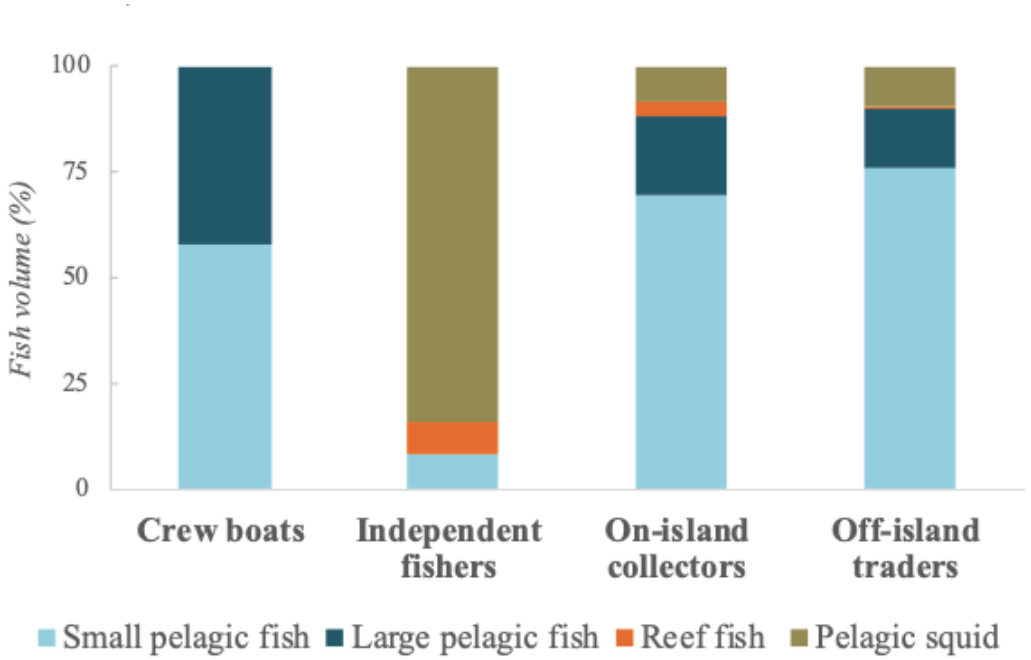


Fig. 2.4. Composition of fish types by volume in the value chain on an average day during the (a) calm and (b) windy seasons. Each actor is ordered in the direction of trade.

(a) Calm



(b) Windy

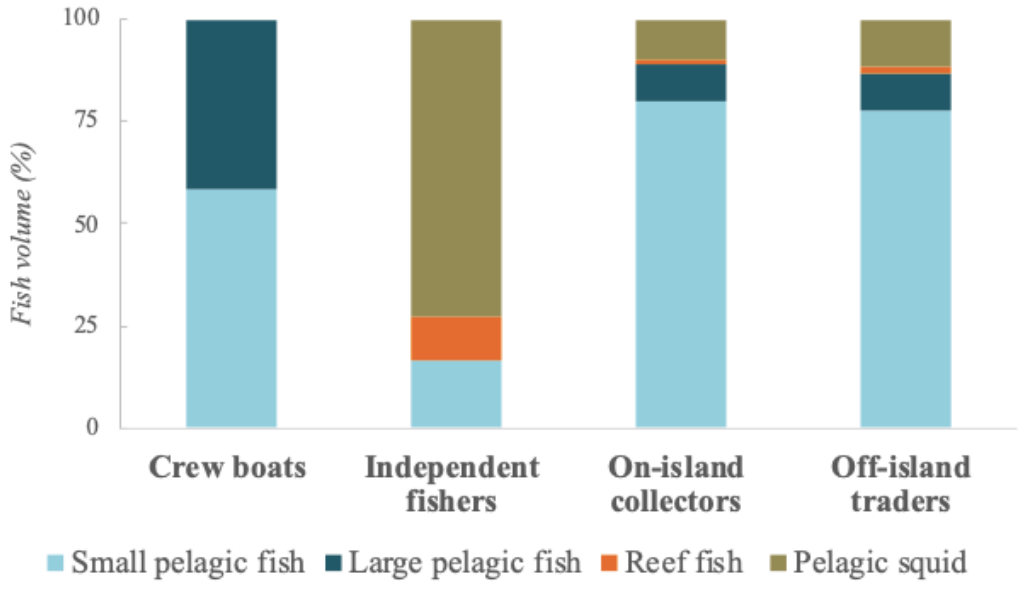


Fig. 2.5. The profit-sharing structure of the Bontosua-Makassar crew-based trade as reported by fishing and trading respondents. The width of the arrows represents the relative proportion (shown in %) of profit from a fish sale going to each actor. The first monetary sale of crew-based catch is made by the auctioneer. The arrow direction shows the order in which the profits from that sale are distributed.

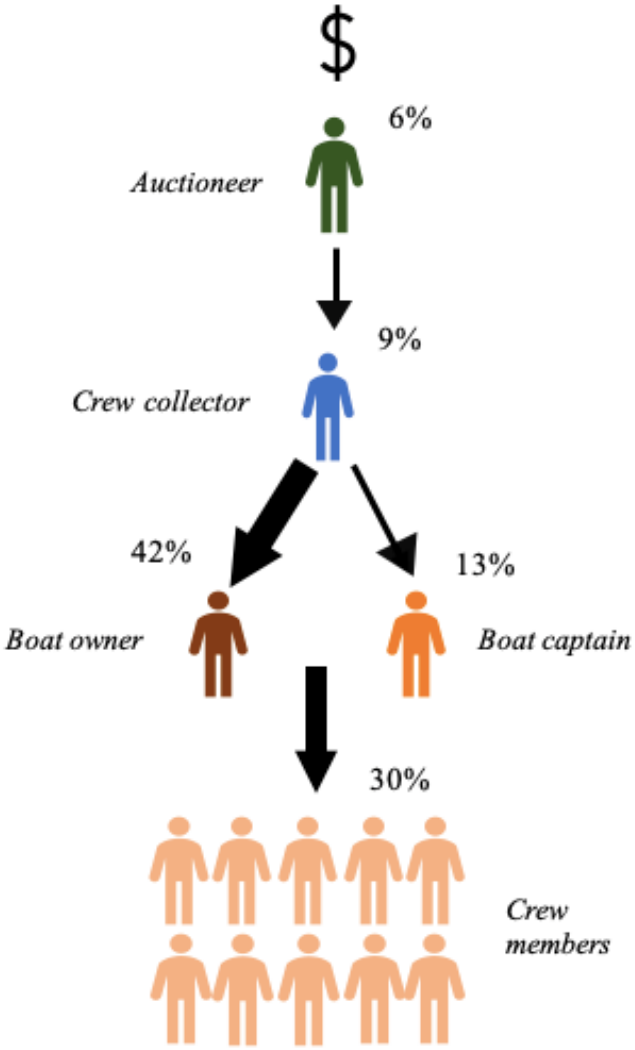


Fig. 2.6. Hourglass trading network of the Makassar value chain shown with actor type and number. Each icon is equivalent to one actor in the chain. The diagram is ordered from top to bottom in the direction of trade (Adapted from Purcell et al. 2017).

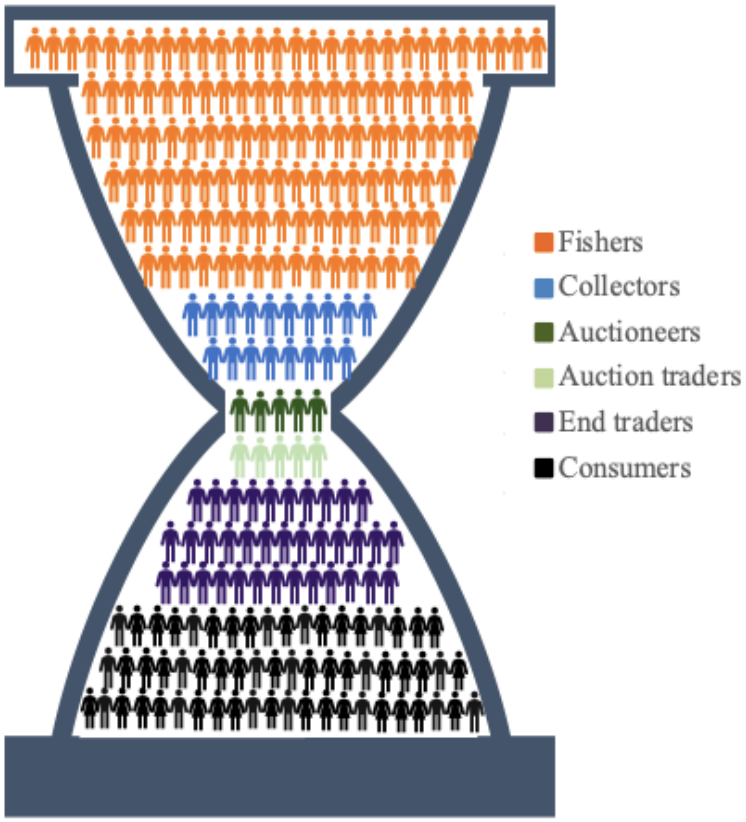


Fig. 2.7. Fish value chain depicting (a) volume (kg) and (b) value for all catch in the calm season. Arrows represent the direction of trade flow from fishers (orange) to on-island collectors (blue) to Makassar collectors (green), Makassar end traders (purple), and finally, consumers in Makassar (black). Arrow (vector) width represents the proportion of value traded, in percentage. Node size indicates the degree of connectedness, based on the number of trade connections going to and flowing from the actor. The dotted lines are existing connections whose values could not be obtained.

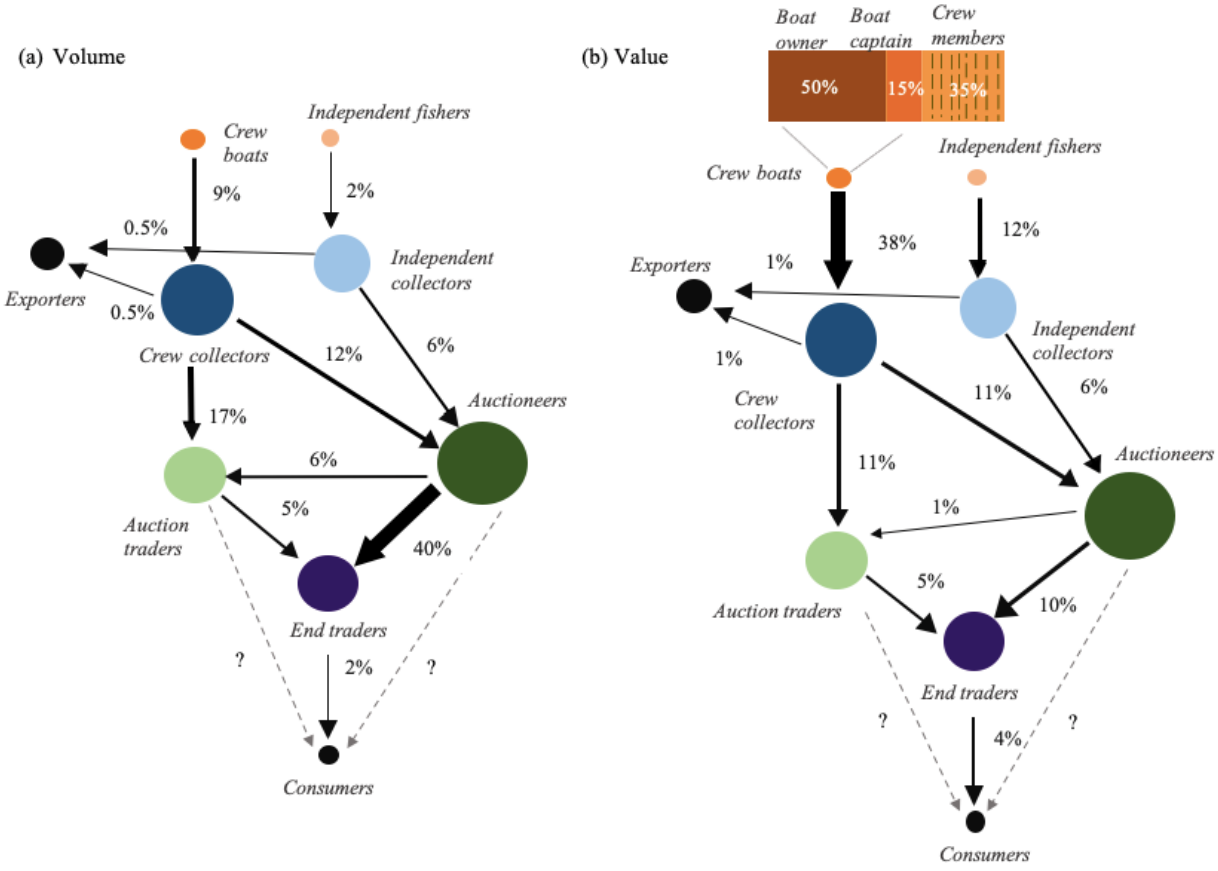
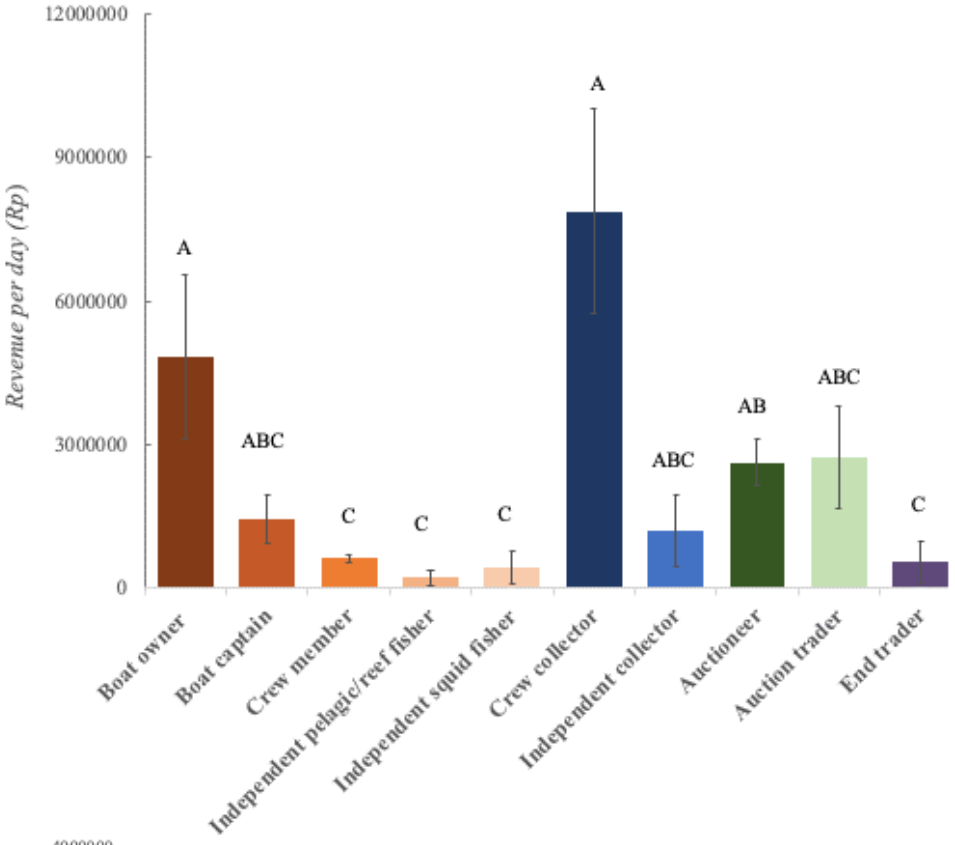
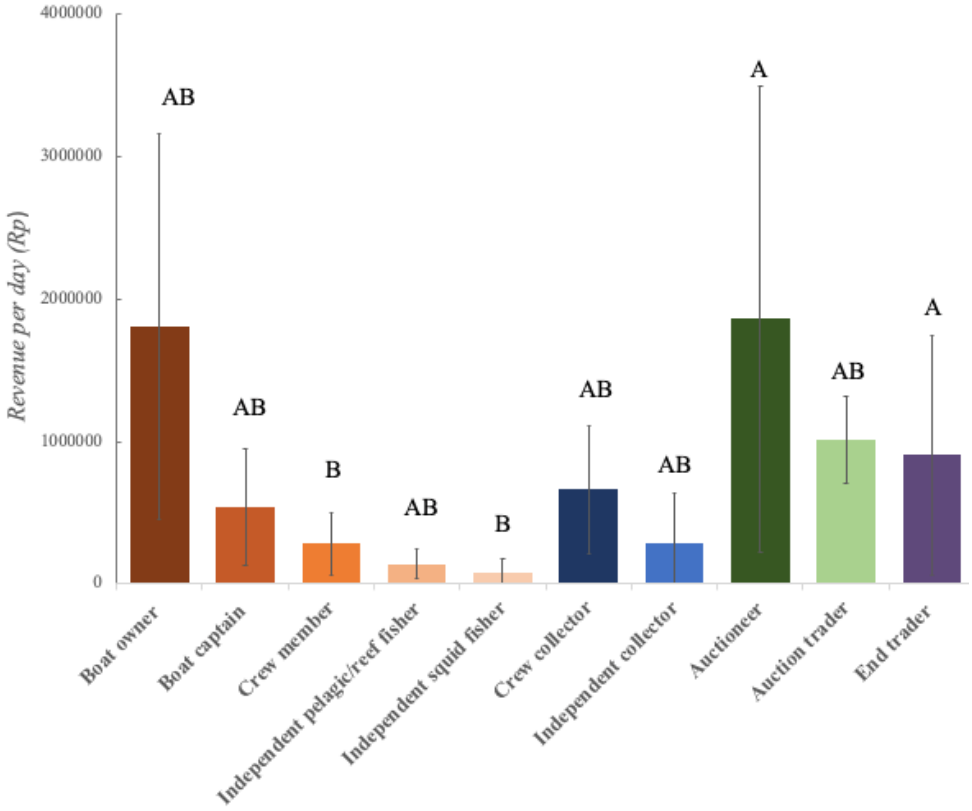


Fig. 2.8. Revenue (Rp) for each actor type on a typical day trading in the (a) calm, and (b) windy season. Error bars represent standard deviation. Letters indicate statistically significant differences ($p < 0.05$).

(a) Calm



(b) Windy



CHAPTER III: Beyond harvest: exploring fish consumption pathways and food security in an Indonesian fishing community

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Manuscript in preparation for submission to the journal *Ecology and Society*.

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Keywords
Fish trade; Spermonde, Indonesia; food and nutrition security; food systems; marine conservation; value chain

Abstract

Coastal communities throughout Indonesia are highly dependent on fish for food and livelihood. However, connections between fish and food security have received limited attention in the national discourse in fisheries management; fisheries in Indonesia are managed according to production-based indicators, despite the important roles that distribution and access play in mediating how fish are used and valued. Similarly, while conservation directives in the region outline food security as a higher-level outcome, the plans do not provide clear strategies for implementing that outcome. Place-based research is thus needed to inform fisheries strategies that are more receptive to local well-being and food security needs. Combining value chain analysis (VCA) and a "fish as food" framework, the following study characterizes links between fish harvest and consumption in a small Indonesian fishing community. Two main questions guide the research: i) How do the island's fisheries influence access to fish for household consumption? ii) What defines fish dependency in this community? Our findings indicate that island harvest and consumption are dominated by small pelagic species caught by commercial fishing crews; however, small-scale fishers play a key role in provisioning fish, and thus supporting food security, during low catch periods. Catch and consumption are seasonally dependent: major declines in harvest during the windy season leads households to reduce their daily fish consumption and substitute with less preferred farmed fish. Evidence of market-based fish trade and strong associations between dietary diversity and other food groups suggest that food security in this community is more related to income from fishing than consumption. For management and conservation to

address food insecurity in coastal communities, the complex factors shaping fish dependence at the local level must be considered.

Introduction

Food insecurity affects a quarter of the global population (Roser and Ritchie 2019). A substantial body of evidence now points to fisheries as uniquely equipped to help address this issue; directly, by offering a crucial source of protein and micronutrients to billions of people worldwide (Allison 2011, Kawarazuka and Bene 2011, HLPE 2014, Hicks et al. 2019), and indirectly by supporting the livelihoods of 10% of the global population (Bene et al. 2015). Additionally, in communities where livelihoods and consumption depend on marine resources, fish is often the basis for culture, identity, and way of life (Bell et al. 2009, Sharma 2011).

In the archipelagic country of Indonesia, the contribution of fisheries to food and nutrition security is indisputable: fish provide up to 54 percent of dietary animal protein and over 6 million people are employed in the fisheries sector (FAO 2014). Several factors present risks to these benefits, including habitat degradation, destructive and overfishing, climate change, foreign fleets, and a growing local and global population (Muawanah et al. 2012, Glaser and Glaeser 2014, Prescott et al. 2015). Concerns over resource sustainability have motivated the goal of "managing marine resources for food security" in Indonesia's Medium Term Development Plan (Ayunda et al. 2018). Improved food security is also one of the higher-level outcomes of the Coral Triangle Initiative (CTI), a partnership between conservation organizations and six nations committed to restoring coral reef health including Indonesia. However, fisheries management plans in Indonesia do not provide strategies for conceptualizing or meeting food security goals despite the increased attention on it as an outcome (Foale et al. 2013, Clifton and Foale 2017).

Coastal communities in Indonesia are often prone to food and livelihood insecurity because they are highly dependent on fisheries for income and subsistence (Bell et al. 2009, Glaser et al. 2015). Attempts to address coastal community vulnerability to food insecurity in Indonesia have fallen short of their intended outcomes in part because of the narrowly defined principles underlying management and conservation (Foale et al. 2013, Clifton and Foale 2017, Gibson et al. 2020). One key assumption directing the discourse is that the availability of fish determines food security (Fiorella et al. 2014, Fabinyi et al. 2017). This assumption, however, ignores the roles that other dimensions of food security- access, utilization, and stability- = in mediating how fish are used and valued. For example, Indonesia's government maintains a strong focus on fish availability, employing production-based indicators such as fish price, catch volume, and income, despite the importance of distribution (i.e. trade within and outside local communities) and consumption (i.e. cultural traditions and nutrition) pathways to food security (McClanahan et al. 2013, Olson et al. 2014, Fabinyi et al. 2017, Tezzo et al. 2020). As a result, technical solutions involving gear and spatial restrictions are the focus of Indonesian management and conservation efforts. That food security is also defined by access and use characteristics directs us to consider not only the ways fish are produced, but also traded and consumed within communities and cultures (Fabinyi et al. 2017).

To overcome the challenges of food security and malnutrition, social science scholars have argued for expanding the view of fisheries not just as the outcome of common pool resource management (McCay and Acheson 1987), but as part of food systems (Clifton and Foale 2017, Farmery et al. 2021). It is believed that food "systems

thinking" best confers resilience and food security by addressing the "multifunctionality" (economic, social, cultural, and ecological aspects) of food through linkages between production and consumption (Tlusty et al. 2019, Farmery et al. 2021). Still today, fish are a rare feature in food systems discourse (Levkoe et al. 2017, Bene et al. 2019, FAO 2020). The "fish as food" framework assists in filling this gap by conceptualizing fisheries as a food system, thereby broadening fisheries research to include interconnected social, environmental, and economic outcomes (Olson et al. 2014, Levkoe et al. 2017, Farmery et al. 2021). Considering fish as *food* rather than exclusively as resources to be managed requires a different set of values rooted in human rights to fish and equity at all stages of the supply chain (Levkoe 2017, Lowitt et al. 2019). As an alternative to the production-based paradigm, the fish as food framing has the potential to address the complexity of food insecurity and malnutrition by considering a broader range of factors that affect access to fish and characterize fish dependence- defined here as the social, cultural, economic, and nutritional value that fish and particular fish species hold in a given context.

As conservation interventions and management seek to accomplish socio-economic objectives through marine protection, understanding the dynamics between production and consumption has never been more pressing (Mello et al. 2010, Bene et al. 2016). Value-chain analysis (VCA) can be a useful tool for examining how harvest-level indicators affect fish access and food security. Although VCAs are designed to assess barriers to livelihood benefits, few move beyond production performance indicators (i.e. income, fish volume, pricing) and upstream actors like fishers and their buyers (Bene et al. 2007, Bell et al. 2009, Thyresson et al. 2013, Kittinger et al. 2015, Rosales et al. 2017,

Bennett et al. 2018). Such perspectives tend to exclude pathways to food security through local distribution and consumption (Bennett et al. 2021). If research is to shed light on the potential for conservation and management to achieve socio-economic outcomes, fish acquisition, consumption, relationships, and cultural preferences are key research gaps (Noack and Pouw 2015, Thilsted et al. 2016, Bennett et al. 2018). How fish are valued and utilized socially, culturally, and economically has powerful implications for conservation and management interventions and the resulting social and ecological changes (Bene et al. 2016, Fabinyi et al. 2017); to the extent that fish are embedded in local economies, social, and cultural contexts, changes to their access can also affect social networks, in addition to access to other staple foods (Bene et al. 2016, Fabinyi et al. 2017).

The fish as food framework has had limited empirical research to date, and most of the available data are regional or national in scale (Bell et al. 2009, Bene et al. 2016, Levkoe et al. 2017, Lowitt et al. 2019). Bene and colleagues (2016) argue that place-based studies are better able to capture the multi-dimensional pathways through which fisheries can contribute to food and nutrition security. Moreover, disaggregated fisheries data at the species level would help assess priorities in conservation, where coral reefs are the current focus in Indonesia. In this study, we use a mixed methods analysis to characterize the links between fish harvest and consumption in a small Indonesian fishing community. Two main questions guide the research: i) How do the island's fisheries influence access to fish for household consumption? ii) What defines fish dependence (i.e. on particular species, traders, and ways of utilizing fish for food security)in this community? In addition to advancing the discourse of fisheries' contributions to food

security and nutrition, our broader aim is to inform conservation and management strategies in the region that are more receptive to local values and needs.

Methods

Study site and context

The Spermonde Archipelago extends approximately 60 km offshore of Makassar in South Sulawesi Province, a popular port for the region's fish trade (Figure 3.1). Out of the approximately 6,500 households dispersed throughout the islands, a majority are involved in fishing full-time (Ferse et al. 2012, 2014). Fisheries are characterized by a variety in gear types and boats that target reef and pelagic areas (Glaeser et al. 2018). A number of intersecting issues have created a "perfect storm" for declining fisheries in the region: poor value chain governance and enforcement, the industrialization of fisheries, and destructive fishing practices (Deswandi 2012). Beginning in the 1960s, Indonesia's government policies shifted fishing practices from subsistence, small-scale operations to commercialized endeavors for regional and global markets (Gorris 2016). These changes, combined with rapid urbanization and development, spurred a nutrition transition characterized by cheap, processed foods (Lipoeto et al. 2013). Obesity and diabetes now pose significant challenges to the national health system in Indonesia (Roemling and Qaim 2012, Lipoeto et al. 2013, Gibson et al. 2020). Although no empirical data exists on household diets in the Spermonde, the region's strong ties to urban development and globalization (Schwerdtner Mañez and Ferse 2010, Sutherland 2011) and nutritional outcomes from other Indonesian fishing communities (Gibson et al. 2020) suggest that island diets in the Spermonde have been similarly affected compared to other studied areas of Indonesia.

The data collection for this study takes place on the island of Bontosua, located approximately one hour from the city of Makassar (Fig. 3.1). Nearly all of the 182 households rely on fishing as their primary source of income. Other livelihoods such as farming are inaccessible to islanders because of limited land and freshwater availability. The people who live on Bontosua possess generational knowledge about fish trading, fish types, and foodways—the ways that foods are valued, acquired, prepared, and eaten. Most households on Bontosua rely exclusively on the fish trade for income (Glaeser et al. 2018). Fishers on the island catch and trade a variety of species that are retained locally or directed to the mainland city of Makassar. The island's diverse fisheries and proximity to a major trading center open up several pathways for household consumption of fish. Seasonality also plays a major role in fish availability on the island, as poor fishing conditions at certain times of the year reduce catch volumes. Fisheries serve myriad social and cultural functions in places like the Spermonde with a traditional history of fishing and limited access to fresh foods (Lowitt et al. 2019).

Data collection

To quantify fish dependence, data on the frequency and volume of individual and household consumption of fish, stratified by species, and their modes of acquisition (i.e. on and off-island trader types) were collected in household surveys. Female heads of house were interviewed because they tend to make the majority of food decisions for households in Indonesia (Asmal et al. 2020, Gibson et al. 2020). The fieldwork took place from December 2019 to February 2020. We applied a stratified random sampling approach by island area, as it is known that different fishing groups reside on the north, south, east, and west of the island (N=4). Using a household list for each side of the

island and a random number generator, we obtained a roughly even subset for each side of the island (N=~16) to reach a total of 62 households. Before the start of data collection, we spoke with a random subset of respondents following the same methodology to identify general fish acquisition patterns, common dishes, and ingredients. These responses informed the finalized version of open and closed-ended survey questions.

The final household surveys gauged access to and utilization of fish for consumption through questions on: i) acquisition pathways (i.e. on or off Bontosua, for free or payment), ii) fish types acquired and their prices, iii) relationships with sellers, iv) factors influencing the purchase decision, v) preference for consuming particular fish types, and vi) the role of fish species in the context of the entire diet. To better contextualize the harvest-consumption link and illustrate how the value chain informs access to fish, survey responses on species-specific data and buying pathways were examined against the island's fish production and trade on Bontosua. This information was gathered through concurrent surveys administered to Bontosua fishers which examined fish consumption preference along with other parameters related to trade: i) fish price, ii) fish volume, iii) points of distribution, and iv) modes of production. The fisher surveys were administered using the same stratified sampling approach as Bontosua households. Market prices were acquired from end traders in the city of Makassar's primary regional fishing port.

Data analysis

All household survey data were analyzed in SPSS Version 26. Frequency of fish consumption by species, seller identity, and fish preference in the consumer surveys were

analyzed descriptively alongside fisher-trader parameters including frequency of harvest and trade by species, proportion retained for household consumption, and fish preference among fishers.

Utilization and stability dimensions were captured with a 24-hour dietary recall, 7-day food frequency questionnaire (FFQ), and food security scale. We used the 24-hour dietary to estimate dietary diversity (DD), an important indicator of micronutrient adequacy (Gibson et al. 2020). The FAO and FHI 360 (2016) guidelines categorize food into 10 food groups (fish/meat/dairy, pulses, nuts/seeds, vitamin A-rich fruits and vegetables, green leafy vegetables, other fruits, other vegetables, eggs, dairy, grains), each of which contribute to the overall dietary diversity score. It is recommended that at least 5 food groups be consumed to achieve adequate micronutrient status, so this number served as our threshold (FAO and FHI 360 2016). A food list created from the pre-survey conversations served as a guide to prompt participants in the event that they could not remember certain items that they ate. To minimize redundancy and burden on participants, responses for the 24-hour recall were in the "I ate" format, and then later converted into "yes" and "no". In doing so, the method reduced recall bias on the part of the enumerator. The recall was followed by the FFQ, a method for assessing the nutritional status of populations with relatively homogenous food intake (FAO 2018). Our study developed a quantitative FFQ with portion sizes in order to assess the contribution of fish to nutritional status. During the interviews, portion sizes were estimated with household dishware (e.g. plates, bowls) and commonly bought and consumed quantities (i.e. handfuls, bunches) and then converted to kilograms for

analysis. Associations between the dietary diversity and food group consumption were tested with Chi-Square and Fisher's exact tests.

We used the food security scale created by Tufts Nutrition (Nord et al. 2002), called the Orissa Food Security Scale. Their module adapted the U.S. Food Security Survey for low-income countries. In this variation, the 18-question U.S. module was modified to 11 questions to reflect seasonal disruptions to income in India. Similar natural shocks are present in the Makassar context during the "windy", or monsoon, season. Another modification made by Nord et al. (2002) to the U.S. Food Security Survey was the reduction of the reference period from 12 months to 30 days to improve recall accuracy. An introductory pilot survey was tested in November 2019 with Bontosua households to ensure that the questions were understood. Each food security score was calculated based on the number of times a respondent answered affirmatively to a question. The scores were then divided into three categories: food secure (0-1 with or without children), food insecure without hunger (2-4 with children, 2-3 without children), and food insecure with hunger (5+ with children, 4+ without children).

Results

Household fish consumption pathways

Survey sampling and key informant interviews identified three main forms of fishing that supplied fish to Bontosua households: medium-sized vessels (~20 GT) (hereafter called crew boats) targeting pelagic fish with purse seine nets; independent fishing for pelagic or reef fish; and independent squid fishing in the nearshore pelagic areas. All independent fishers- an umbrella term which includes both independent pelagic/reef fishers and squid fishers- are considered small-scale fishers in Indonesia

because they operate vessels under 10 GT in size (De Alessi et al. 2017). A variety of fishing formats allowed households to consume a wide range of species; 15 distinct reef species and 14 pelagic species were reported by Bontosua households. The following section highlights the 5 fish types consumed by households- small pelagic, large pelagic, reef, pelagic squid, and farmed- and the ways in which they were acquired during the calm (high catch) and windy (low catch) seasons (Table 3.1). Small and large pelagic species were distinguished by their size: species whose listed common length on FishBase was 30 cm or less were grouped into the small pelagic category ((FAO 2004, Rountos 2016, Braham and Corten 2015, Froese and Pauly 2021)).

Calm season

Throughout the calm season, fish were mainly acquired for free through surplus catch from the island. Ninety-three percent of the fish consumed by weight across households consisted of fish caught by islanders and exchanged for free, while only 7% was purchased from traders or fishers on-island. Most of the on-island supply originated from crew boats, which harvested small and large pelagic species that totaled 78% of the island's total catch volume on a typical day in the calm season (Fig. 3.2). Independent fishers harvested the remaining catch, divided between small pelagic (2%) and pelagic squid (19%). No large pelagic species were reported in the small-scale catch. A small portion (3%) of the fish caught by Bontosua fishers was kept for daily household consumption and exchange in the calm season, while the rest (97%) was traded off-island or made available for on-island purchase.

During the calm season, catch and consumption were mainly composed of small pelagic species. Fifty-eight percent of the total volume consumed by households (Fig.

3.3) and 48% of the total volume caught on Bontosua (Fig. 3.2) came from small pelagic fish. Additionally, the types of fish most commonly given away by fishers matched the two most consumed species: long-jawed mackerel (*Rastrelliger kanagurta*; local name "banyara") and oxeye scad (*Selar boops*; local name "katombo"), both in the small pelagic fish group. Ninety-five percent of households (N=62) reported consuming either or both of these species.

Although large pelagic fish were ranked second in catch volume to small pelagic fish, households derived their second largest portion of fish from the seasonal pelagic squid fishery (Fig. 3.3). Large pelagic species were the next most popular fish type (15%), while reef fish was the least popular wild-caught fish type at 6% of the total volume consumed and 1% of the total catch. Thirteen percent of households (N=62) had reported consuming reef species during the calm season.

Windy season

Consumption patterns and pathways shifted during the windy season as pelagic crews experienced a 71% decrease in harvest (Fig. 3.2). In this low catch period, overall consumption of wild captured fish decreased by approximately 60%, and total fish consumption decreased by 25% (Fig. 3.3). Small pelagic species remained the top species caught for consumption at 53% by volume. However, as surplus catch became scarcer, the average number of days per month that households bought fish increased significantly ($Z=-6.754$, $p<0.0001$) and 80% of the total catch consumed was purchased (Fig. 3.4). To fill the gap left by the loss of wild catch, islanders purchased a farmed fish called milkfish (*Chanos chanos*; local name "bolu"); a majority of the purchased fish volume (54%) and nearly half of the consumed volume (44%) during this season consisted of

milkfish. The only pathway households obtained this fish was through individual off-island traders who traveled to Bontosua on days where no fishing was anticipated. Similar to the calm season, the composition of consumed and caught fish differed. While equal parts large and small pelagic fish comprised the overall fish catch (Fig. 3.2), small pelagic fish made up a majority of the consumed wild-caught fish (66%) followed by large pelagic (15%), reef (15%), and pelagic squid (4%). (Fig. 3.3).

Responses detailing the identity of on-island fish sellers revealed different origins for sale versus on-island sharing of wild-caught fish. While sharing appeared to be most common in pelagic fishing crews, sale of catches occurred mostly with independent fishers. With the exception of three buying interactions with crew members or independent collectors, all the purchasing of wild-caught fish involved independent fishers (Fig. 3.4). Most of the pelagic fish supplied to households (65%) in the windy season came from sales with independent fishers, and over half of consumers (55%, N=62) purchased from them. Of the consumers who reported relying on sellers for fish (N=34), none reported pelagic crews or on-island traders, but 26% listed one or more independent fishers.

While reef fish consumption was negligible during the calm season, species of this type played a more substantial role during low catch periods. Thirty-nine percent (N=78) of regular buying interactions involved traders of reef fish, which included Bontosua reef fishers along with the outside traders who would also supply farmed milkfish. Only one wild-caught fish- a reef fish known locally as *jannati*- increased in the amount consumed and the number of consumers from the calm to windy season. The consumed amount increased sixfold, and the number of consumer households increased

from 3 to 16. The higher consumption level of this species was the main driver for an overall increase in reef fish consumption across households: from 8 households (13%) in the calm season to 20 (32%) in the windy season. Conversely, the number of consumers eating pelagic fish reduced from 62 (100%) to 39 (63%) in the windy season.

Factors affecting household fish buying patterns

Both flexibility and need defined the buyer-seller relationships on Bontosua. A majority of consumers (55%) reported relying on one or more of their fish sellers to meet their daily needs. Of these, 74% were milkfish sellers and 26% were independent fishers. In all but one of these relationships (N=32), consumers felt able to replace the seller if a different seller offered a better price or assistance.

Most consumers (61%; N=62) adjusted their buying habits to changes in the price of fish. Coping strategies for when fish prices were high included buying cheaper kinds of fish (44%), reducing the amount of fish purchased (28%), or replacing fish with cheaper staples (28%). The most popular response to the question, "what factors affect which fish you buy?" was "no other options", an experience shared by 79% of respondents. Other constraints included price or income, which affected the decisions of 66% of respondents, and loyalty to sellers who are family or friends (16%). The preference-related factors included desire (24%) and taste (39%).

Households tended to purchase less expensive fish on the island. Small pelagic species had significantly lower average market prices during the calm (*Welch's F* (3, 31.98)=52.98, p<0.001)) and windy (*Welch's F* (3, 47.57)=49.76, p<0.001)) seasons (Fig. 3.5) than any other fish type caught on the island. Reef species tended towards the more expensive end, though in the calm season, the association was only significant compared

to pelagic fish (p <0.001). In the windy season, Games-Howell post hoc tests stratified each fish type by market price levels. Large pelagic species fetched the highest prices (68037 ± 28170 Rp), followed by squid (52778 ± 3632), reef (45833 ± 4618), and small pelagic species (28425.93 ± 10927) (Fig. 3.5). Windy season prices of large pelagic species were on average 28% more expensive than squid, 48% more expensive than reef, and 143% more expensive than small pelagic fish.

Preference and importance of fish species to consumers

A fish ranking activity in the household surveys gauged the importance of fish species consumed by households. Consumers were asked to rank the species that they reported consuming as a household. Importance was left as subjective to the respondent; most women chose to evaluate each species based on taste (66%) or what was most often eaten in their household (19%) (N=53). Three small pelagic species- long-jawed mackerel (*Rastrelliger kanagurta*; local name "banyara"), oxeye scad (*Selar boops*; "katombo"), and sardines (*Sardinella gibbosa*; local name "tembang")- had the highest average ratings (Fig. 3.6). These species were also the most popular, measured by the proportion of households who reported eating them on a typical day during the calm and/or windy season. The fourth most important species was a reef triggerfish (*Balistapas undulatus*; local name "papakulu"). Besides this one fish, most of the documented reef species were in the "least consumed" and "least important" quadrant.

To the survey question, "do you prefer eating milkfish or wild-caught fish?", most women (74%) said wild-caught. Negative attributes of milkfish given by women including high bone content (30%), high cholesterol (23%), and general dislike (13%) justified the preference for wild-caught fish. Other reasons included the cheap/free cost

(15%), taste (15%), and custom (5%) associated with wild-caught fish. When asked to elaborate on which species they prefer over milkfish, all but four respondents out of 53 listed one or more commonly consumed small pelagic fish species. Two others included skipjack tuna (*Katsuwonus pelamus*; local name "cakalang"), a large pelagic species, and two listed one or more reef species (Table 3.2). When asked the same question, 91% of fishers (*N*=53) chose wild-caught fish. The main reason was taste (58%), followed by the dislike of high bone content in milkfish (15%), the "free" cost of wild-caught fish (15%), and health benefits compared to milkfish (10%). One individual mentioned that their avoidance of milkfish was due to "doctor's orders". Similarly, all but one respondent included small pelagic species in their preference list. Three respondents listed skipjack tuna (*Katsuwonus pelamus*; local name "cakalang") and two listed reef species (Table 3.2).

For a more granular characterization of fish buying decisions during the windy season, consumers were asked whether they bought more farmed fish or other types, and to explain their reasoning. A majority (63%) chose milkfish, with most (86%) doing so because it was the only fish available for purchase. For the remaining population (37%) who purchased other types of fish more often, a wider array of reasons were presented: preference for wild-caught fish/ dislike for milkfish, cheaper prices, health, and unreliability of the milkfish sellers, who were not always able to travel to the island. A handful of respondents noted that milkfish was most expensive during the holidays and full moon when demand was high and fishing activity low. When asked if fishers ate milkfish on a regular basis, 90% responded affirmatively. Their reasons related mostly to

their availability during the full moon (91%), when a majority of fishers on Bontosua did not fish.

Role of fish in diets and food security

The food frequency questionnaire (FFQ) and 24-hour dietary recall identified fish as the most frequently consumed animal protein source. Ninety-eight percent of women (*N*=55) had consumed fish in the last 7 days, and 69% had eaten fish in the previous 24 hours. Egg was the next most common animal protein and was present in the diets of 80% of women heads of house in the last 7 days and 67% in the 24-hour recall. Chicken and beef were consumed by fewer respondents (Fig. 3.7).

Individual consumption of fish species

The women surveyed had consumed a wide variety of fish species individually: on average, 2 (± 1.07) in the previous day and 7 (± 2.48) in the previous week. The most commonly consumed fish species in the 7-day recall were small pelagic species and milkfish. Long-jawed mackerel (*Rastrelliger kanagurta*; local name "banyara") (44%), milkfish (*Chanos chanos*; local name "bolu") (43%), oxeye scad (*Selar boops;* local name "katombo") (38%), ponyfish (*Karalla dussumieri*; local name "bete-bete") (36%), and sardines (*Sardinella gibbosa*; local name "tembang") (22%) were most popular based on the proportion of consumers eating. Overall, 85% of women had eaten small pelagic fish, 5% had eaten large pelagic fish, and 42% had eaten milkfish in the previous week. Reef fish had been consumed by 14% of women, amounting to 4% of the total volume. In the 24-hour period, the most commonly consumed fish products were sardines (*Sardinella gibbosa*; local name "tembang") (41%) and dried fish (28%) based on the proportion of women eating fish. Only 15% had eaten milkfish, 13% had eaten long-

jawed mackerel (*Rastrelliger kanagurta*; local name "banyara"), and 18% had consumed ponyfish (*Karalla dussumieri*; local name "bete-bete").

Contribution of food groups to dietary diversity

According to the 24-hour recall, 65% of women had achieved dietary diversity, defined as consuming more than four food groups in a 24-hour period (Figure 6). All respondents had eaten rice, a component of the "grains" food group. Other food groups eaten by the majority included meats/poultry/fish (85%), vitamin-A rich fruits (80%), other fruits (71%), and eggs (67%). Other vegetables (38%), green leafy vegetables (29%), nuts/seeds (27%), and pulses (24%) were less common in the diet. No respondent had eaten dairy.

Three food types were staples across a majority (>50%) of respondents who achieved and did not achieve minimum dietary diversity: grains, vitamin A-rich fruits and vegetables, and fish. Chi-square and Fisher's exact tests showed that consuming each of the food groups besides beef (p=0.156, Chi-square test) improved the likelihood of meeting dietary diversity. Seventy-four percent of those who consumed fish achieved dietary diversity compared to 47% of those who did not, a difference that was weakly significant (p=0.055, Chi-square test). Food groups demonstrating the strongest association with achieving dietary diversity included other fruits, other vegetables, and green leafy vegetables (Table 3.3). Based on the odds ratio, those who ate other fruits were nearly 14 times more likely to meet the minimum dietary diversity requirements than those who did not include it in their diet. Nuts/seeds (p=0.001, Fisher's exact test) and pulses (i.e. legumes) (p=0.006, Fisher's exact test) were highly significant, however confidence intervals could not be generated because the category of those who failed to

meet dietary diversity and achieved minimum dietary diversity had no respondents. For the food group categories not included in dietary diversity, sweet foods had a significant negative association with achieving dietary diversity (p=0.040, Fisher's exact test), while savory foods (p=1.00, Fisher's exact test) and sweet drinks (p=1.00, Fisher's exact test) were not statistically significant.

Just over half of the population (58%) had experienced some form of food insecurity in the previous 30 days. Forty percent could be classified as having "food security without hunger", or exhibiting low food security, while 18% had "food security with hunger", or very low food security. This meant that 42% were "food secure", or had high food security (Fig. 3.8). When asked to classify their family's consumption habits in the previous 30 days, most (74%) chose the statement "enough but not always the kinds of foods we want". Twenty-four percent believed that they had enough of the kinds of foods they wanted, while only one individual classified their household's eating habits with the phrase "sometimes not enough to eat". Just over half (54%, N=61) of women reported spending 65% or more of their income on food, placing them in the "high to very high" category for expenditures. A minority of women (46%, N=61) had medium or low average expenditure.

Discussion

Managing fisheries for food security will become increasingly necessary as trends continue toward resource degradation, marine use conflicts, and greater reliance on fisheries resources in coastal developing communities (McClanahan et al. 2013, Paddock 2017). The ways in which fisheries are embedded into households and communities have important implications for the strategies offered to protect and improve food security.

Numerous studies point to the importance of fishing as a livelihood for coastal communities in the Spermonde region of Indonesia (Deswandi 2012, Ferse et al. 2014, Nurdin and Grydehoj 2014, Glaeser et al. 2018); to our knowledge, this study is the first in the region to document the specificities of their consumptive importance. By illustrating pathways from catch to consumption, we have provided a baseline understanding of fish access and utilization at the island level. Our findings concur with studies in other small fishing communities on the basis of high consumption of lower-value small pelagic species (Adhuri et al. 2016, Glaeser et al. 2018, Gibson et al. 2020), subsistence pathways (Bell et al. 2009, McCoy et al. 2018, Gibson et al. 2020), and the responsibilities of women in procuring household nutrition (Harper et al. 2017, Gibson et al. 2020). To this body of data we have added richness by identifying three main characteristics that define on-island fish acquisition and dependence: i) dominance of small pelagic species, ii) provisioning by small-scale fishers, and iii) income-based food security. This evidence points to the need to elicit multi-directional relationships between production, provisioning, and consumption (Tezzo et al. 2020). A strong understanding of the pathways through which fish contribute to household consumption is essential for adequately addressing the food security goals on the island of study and for island communities in the Spermonde region more generally.

Role of small pelagic species

A production-based focus on fisheries tends to obscure access and utilization dimensions of food security (Kawarazuka and Bene 2010, Tezzo et al. 2020). This is no exception in Indonesia where data on fish consumption, especially disaggregated by fish species, are scarce (Gibson et al. 2020, 2021). Catch, acquisition, and consumption

indicators show that small pelagic species were dominant on Bontosua. This appears to be motivated by the activity of pelagic fishing crews, which landed small pelagic species in higher numbers overall, per boat, and per capita than independent fishers on the island. The contribution of fishing crews to subsistence is also substantial; two kinds of small pelagic fish commonly caught by crew-based fishers—long-jawed mackerel (*Rastrelliger kanagurta*) and oxeye scad (*Selar boops*)-- were reported more often to be kept for at-home consumption than any other fish species. The patterns are representative of other studies depicting purse seine fisheries as the most productive and popular of fishing modes in Indonesia (Pet-Soede et al. 2001, Nelwan et al. 2020).

In the windy season, small pelagic species continued to be important to the island's catch. However, consumption patterns shifted in response to reduced fish volume. Farmed milkfish comprised nearly half of all fish consumed by surveyed households- a dependence noted anecdotally in the Spermonde, but never quantified (Deswandi 2012, Ferse et al. 2012). Even with the popularity of this fish, a vast majority of women and fishers in the study preferred eating small pelagic fish and considered those species most important. Reasons provided for this preference included taste and texture, health, and affordability, while importance was based on taste and availability. Additional evidence supports a number of the community perspectives provided in the study. For instance, low market price is one of the most commonly cited factors driving widespread consumption of small pelagic species in other developing coastal areas (Thyresson et al. 2013, Belton and Thilsted 2014, Adhuri et al. 2016). Small pelagic species have also been recognized for their nutritional role in low-income countries like Indonesia where micronutrient deficiencies (e.g. iron, vitamin A) are a concern, as many

contain higher levels of iron, calcium, zinc, and vitamin A compared to larger farmed and wild species (Kawarazuka and Bene 2011, Reksten et al. 2020). Only one study in Indonesia has assessed the micronutrient content of milkfish (Malle et al. 2019), and to our knowledge no comparative studies have been done. Milkfish is one of the most popular fish species for low-income households the Philippines, a neighboring country (Salayo 2010); however, the value chain analyses performed there are aimed at production parameters, which limits conclusions that can be drawn about their current or potential value to coastal communities (Roxas et al. 2017, Salayo et al. 2021). Given that aquaculture production is expected to overtake Indonesian capture fisheries by 2030 (Tran et al. 2017), research on access and nutritional parameters of farmed milkfish in Indonesia is warranted. Future research would also benefit from a greater understanding of the cultural, nutritional, and social values assigned to fish, as they can play an important role in shaping localized consumption patterns (Noack and Pouw 2015).

Small-scale fishers are important for on-island sale

In the study results, a particular focus is paid to the windy season since this is the most vulnerable time for harvest and nutrition on the island. A 71% decline in harvest leaves little surplus for on-island subsistence, thereby shifting acquisition patterns to purchase over sharing. To supplement the loss of free catch from fishing crews during this time, two main actors - milkfish sellers from Makassar and on-island independent fishers- sold a majority of the fish consumed by households. Many women reported relying on milkfish sellers, but their buying ties were fluid: only one respondent reported being unable to switch to another seller that they relied upon if they were dissatisfied with their service. For those remaining, most would buy from another seller if there were

other sellers or if a milkfish seller did not arrive on the island that day. The general feeling among most consumers (75%), however, was that there was not enough variety in the fish available for sale.

A desire for more preferred wild-caught species may help explain the disproportionately strong presence of independent fishers in sale. While independent fishers targeting pelagic and reef fish harvested only 3% of the total Bontosua catch on a typical day during the windy season, they sold nearly 40% of the fish eaten by households. Similar to Bontosua, coastal communities worldwide rely heavily on catch from small-scale fisheries, as they tend to be defined by subsistence and local scale (Smith and Basurto 2019).

As shown in this study, seasonal conditions make disaggregating catch across time paramount. While our study captured comparative seasonal data with estimates, time-series scales would have depicted more realistic food consumption habits. Furthermore, since households were asked to list all of the species they consumed on a typical day in each season, it is likely that the absolute amounts acquired were overestimated (FAO 2018). We attempted to account for this discrepancy by gathering data on individual fish consumption in a 7-day period, but the recalls relied on memory. Other factors leading to misestimation include social desirability bias, as beliefs among community members that healthy foods may be viewed more favorably could have led to inaccurate reporting of portion sizes and/or frequency in the FFQ. Participant observation of meals and meal types could have eliminated some of this potential bias. Similarly, buyer-seller interactions were documented through recounts with women heads of house, rather than observing interactions as they occurred. Building from this research,

ethnographic studies could capture the real-time complexities inherent to buying, sharing, and consumption of fish on the island that were beyond our scope (Noack and Pouw 2015, Rodrigues and Villasante 2016).

Income-based food security

Coastal developing states often exhibit mixed modes of reliance on fish ranging from subsistence to market-based (O'Garra 2012, Kittinger et al. 2015, Charlton et al. 2016). In some Pacific Island settings, for example, only a small fraction of catch goes to market (Bell et al. 2009, Kittinger et al. 2015). On the other hand, a common feature among full-time fishing households is that fishing is more associated with an exchange economy than subsistence. The justification is two-fold: fishing households cannot only live on fish (Fabinyi et al. 2017), and market pressures encourage sale (Brewer 2011, Thyresson et al. 2013, Ferse et al. 2014). Fishing economies with these attributes have been documented in resource-dependent communities such as Kenya (Fiorella et al. 2014) and the Philippines (Fabinyi et al. 2017). That ability to sell fish and buy other foods is what appears to define food security on Bontosua.

Consumption data confirm that fish are a staple item in household diet, representing a majority of animal source protein consumed at the household and individual level. Even with the 7-day recall occurring in the windy season, women reported consuming two times more fish than the national average (KKP 2018). Yet, the consumption of fish was only weakly associated with achieving dietary diversity. Stronger associations with other food groups, and their relative scarcity in household diets, suggests that access to fish is not at risk in this community. Rather, the ability to access other foods with income may be crucial for improving food security indicators.

Similar to other tropical locations such as Kenya (McClanahan et al. 2013) and Pacific Island communities (Corsi et al. 2008, Charlton et al. 2016), plant sources of protein, including legumes and nuts/seeds, were far less common in Bontosua diets. These and other nutritionally dense food groups including green leafy vegetables are only available for sale on the mainland of Makassar. Aside from fish, the only on-island offerings consist of cheaper packaged sweets and fried snacks. Given these barriers to access, the negative association found between eating sweet foods and achieving dietary diversity is concerning but expected. Diet transformations in coastal communities are highly relevant, as food security rests not only on access to sufficient food, but nutritious food. Indeed, globalization has pushed many remote island communities to become highly dependent on imports at the expense of more nutrient-dense foods (Hughes and Lawrence 2005, Corsi et al. 2008, Englberger et al. 2010, Thow et al. 2011).

Only around 5 to 10% of the total catch on Bontosua was shared on-island or kept for consumption. Several pieces of evidence help to explain this low level of subsistence. In our study, the least consumed fish types- reef, pelagic squid, and large pelagic- were more expensive than small pelagic species in Makassar markets. Large pelagic fish- the most expensive of the types analyzed- made up a larger proportion of catch than consumption. Across the Spermonde and other areas of Indonesia (Ferse et al. 2012, Ferse et al. 2014, Adhuri et al. 2016, Fabinyi et al. 2017, Glaeser et al. 2018), the sale of high-value fish is a quintessential marker of market-based trade. A strong market pattern defined by commercial crew-based vessels is consistent with Indonesia's political history. During the nation's bid to grow their global fish trading capacity in the 1960s and 70s, subsidies began to squeeze out subsistence-based small-scale fisheries in favor of high-

volume purse seine fleets, amplifying national and international trade (MacFadyen and Corcoran 2002, Deswandi 2012, Prescott et al. 2015).

If fish consumption were the primary determinant of food security, we would expect a fairly uniform distribution of food security scores with regular fish consumption. Instead, the population was split amongst food-insecure and food-secure categories. Taken together, this is further evidence supporting previous assertions that fisheries income, not consumption, defines food security on Bontosua (Vandenberg et al. 2021). While often an afterthought in marine conservation, the "cash crop" functions of fisheries can be foundational to food security (Allison 2011, Fabinyi et al. 2017). Benefits to food security from trade are often dependent on power relations (Allison 2011); on the island, several different fishing and trading professions exist, accompanied by an equally wide range of revenue and other socio-economic benefits. To ensure more equitable distribution of socio-economic benefits, trade analyses are required that consider the factors structuring these outcomes.

In order to assess how changes in fishing income would affect food security, understanding financial flows at the household level is a necessary follow-up to this study. It has been shown that greater control of income by women is associated with higher dietary diversity and nutritional outcomes for children (Quisumbing 2003, Smith 2003). When men control livelihood outcomes for the household, greater limits are often placed on allocation within the household (Meinzen-Dick et al. 2011). As knowledge of the dynamics of financial control within the household are limited on this island and elsewhere in the Spermonde (Glaser et al. 2015), more studies linking women's autonomy, livelihoods, and food security outcomes are needed to understand how

interventions at the household level could best improve food security outcomes (Weeratunge et al. 2014, Bennett et al. 2018).

The conclusion that fishing income is the main driver of food security should not detract from the subsistence value of fish. In addition to their significant contributions in diets, fish contribute to social cohesion, featuring prominently in sharing and cultural use (Kittinger et al. 2015, Charlton et al. 2016, Fabinyi et al. 2017). Here, we demonstrated that households assigned social and cultural values to particular fish species. A better understanding of the cultural and social factors that define subsistence use would help to establish a baseline for management to sustain these values in communities.

Management and policy implications

With this study, we set out to understand household acquisition in a single fishing community, with the goal of informing conservation and management across the Spermonde region. In considering policy implications, several issues emerge. At the broader level, this research supports the need to move away from a sole focus on the connection between harvest and livelihoods (Fabinyi et al. 2017, Bennett et al. 2018, Bennett et al. 2021). Increasingly, management and conservation efforts in Indonesia have adopted food security goals (Foale et al. 2013). However, proposed links between fish and food security in management and conservation are based mainly on the availability of fish stocks (Fabinyi et al. 2017). Determining more detailed connections between harvest, acquisition, and consumption can broaden the policy scope for addressing food security (Foale et al. 2013, Bennett et al. 2018).

In reflecting on the discussions above, it is imperative that small pelagic fish be given greater priority in management. Like many islanders across Indonesia (Deswandi

2012, Clifton and Foale 2017), fishers on Bontosua depend on small pelagics for food and income. Specialized fishing households are especially high-risk for food insecurity because they face critical tradeoffs between sale and consumption (Gibson et al. 2021). High domestic demand and industrial catch methods have led to severe depletion of pelagic stocks in Indonesia (Ferrol-Schulte et al. 2015), but these issues have received less attention in marine conservation than reef-based fishing (Foale et al. 2013, Clifton and Foale 2017). Our study is further evidence that balancing resource use and conservation in pelagic spaces is an essential challenge.

The nutritional conclusions in this study underscore the need for coordination among fisheries and public health sectors (Bene et al. 2016, Bennett et al. 2021). Islanders on Bontosua, especially women, suffer from diabetes (Lampe et al. 2020), a condition with strong connections to poor diet(Stefani et al. 2018). Incomes from the fish trade enable the purchase of fruits and vegetables off-island and are therefore crucial for supporting dietary diversity. Focusing on improving access to fresh foods through a multi-pronged approach- promoting equity in the fish trade and programs to grow produce on the island- may realize greater progress than any fisheries management measure that focuses on increasing fish production (Fabinyi et al. 2017). Nutritional measures like these could also place greater importance on conserving the on-island pathways for nutrient-dense small pelagic fish such as ponyfish (*Karalla dussumieri*; local name “bete-bete”), which has higher levels of micronutrients than other fish in our study (Reksten et al. 2020).

The impact of conservation and management on food security is mediated by a range of social, political, and cultural factors (Clifton et al. 2013, Fabinyi et al. 2017).

Preference for small pelagic species is one socio-cultural dimension that we found in this study. The statement best describing household food patterns on the island- “enough but not always the kinds of foods we want”- invokes the desire to satisfy needs beyond nutrition. Food habits develop with repeated interactions, giving rise to beliefs, values, norms, and taboos that can influence consumption (Belton and Thilsted 2014, Lyana and Manimbulu 2014, Noack and Pouw 2015, Gibson et al. 2020). Fish preference has been measured in developed countries, but few applications pertain to well-being (Kawarazuka and Bene 2010). If food security is about more than just “sufficient” or “nutritious” food, but “preferred” food, some alternative questions might be considered by managers: i) how will management actions impact the ability of communities to access culturally appropriate food; ii) what are the aspirations of this community in achieving better access to food?

In light of the rise of community-based marine conservation and food security goals in countries such as Indonesia, scholarly arguments have increasingly taken the stance that projects must do more to incorporate the multi-faceted links connecting fisheries to food security outcomes (Bennett et al. 2021). Our study worked from the framework “fish as food” and argues that tracing the multifaceted socioeconomic and cultural value of fish within the community is a key element in this vision. Incorporating social dynamics of the value chain into the structure of planning would allow initiatives to honor and leverage multiple interacting factors to achieve conservation and management success. From this perspective, future policies can better predict and understand the consequences of marine management and shifting supply, and be prepared

to enact a food security framework which matches the needs and function of heterogeneous coastal communities.

Acknowledgments

We wish to thank our enumerator Irsan and translator Farhan Muhatar, in addition to Universitas Hasanuddin for hosting our scholarship. This work was supported by a joint grant from MARS Symbioscience and the University of Rhode Island. Permits for this research were issued by the Indonesian Ministry of Research. The views expressed herein are those of the authors and do not necessarily reflect the views of their agencies.

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Tables

Table 3.1. Fish species included in the fish acquisition portion of the consumer surveys, stratified by fish type.

Fish type	Fish species		
	Scientific name	Common name (English)	Common name (Makassarese)*
Small pelagic fish	*Rastrelliger kanagurta*	Long-jawed mackerel	*Banyara*
	Selar boops	Oxeye scad	*Katombo*
	Sardinella gibbosa	Goldstripe sardine	*Tembang*
	Decapterus macarellus	Mackerel scad	*Layang*
	Karalla dussumieri	Dussumier's ponyfish	*Bete-bete*
Large pelagic fish	*Sphyraena qenie/jello*	Pickhandle/blackfin barracuda	*Asa-asa*
	Katsuwonus pelamus	Skipjack tuna	*Cakalang*
Reef fish	*Siganus lineatus*	Golden lined spinefoot	*Baronang*
	Balistapas undulatus	Orange-lined triggerfish	*Papakulu*
	Unknown	Unknown	*Jannati*
Pelagic squid	*Loligo spp.*	Mixed pelagic squid	*Cumi teropong*
Farmed fish	*Chanos chanos*	Milkfish	*Bolu*

Makassarese is the local language spoken in Makassar and on Bontosua Island.

Table 3.2. Proportion of consumers (*N*=62) and fishers (*N*=53) on Bontosua who preferred eating wild caught to farmed fish, and the fish types that they included in their responses. The sample sizes for proportions preferred refers to the number of times that a species was mentioned in the consumer (*N*=57) and fisher (*N*=66) survey responses. Each respondent could list multiple species in their responses.

Type of respondent	% who preferred wild caught to farmed fish	Proportion of wild-caught fish types preferred		
		Small pelagic	Large pelagic	Reef
Consumer	74%	91%	5%	4%
Fisher	91%	77%	13%	10%

Table 3.3. Association between consuming a food group (*N*=55) and achieving dietary diversity, with the food group "meats/poultry/fish" stratified into its subgroups. The "consumed and met" category is the proportion of those consuming the food group who achieved minimum dietary diversity (>4 food groups). The "not consumed and met" category is the proportion of those who did not consume the food group and achieved minimum dietary diversity. The odds ratio, CI, and p-value outputs are derived from Chi-square and Fisher's Exact tests.

Respondent's consumption of ___ (Y/N) (*N*=55)	**Consumed and met**	**Not consumed and met**	**Odds ratio**	**95% CI**	***p* value**
Vitamin A-rich fruits and vegetables (80%)	73%	36%	4.67	1.15-18.85	**0.035**
Other fruits (71%)	82%	25%	13.71	3.40-55.40	**<0.001**
Fish (69%)	74%	47%	3.14	0.95-10.41	0.055
Eggs (67%)	76%	44%	3.89	1.18-12.85	**0.022**
Chicken (45%)	80%	53%	3.50	1.04-11.79	**0.049**
Beef (15%)	88%	62%	0.59	0.13-2.65	0.156
Other vegetables (38%)	90%	50%	9.50	1.91-47.27	**0.002**
Green leafy vegetables (29%)	88%	56%	5.40	1.08-27.09	**0.033**
Pulses (31%)	100%	55%	N/A	N/A	**0.006**
Nuts/seeds (27%)	100%	53%	N/A	N/A	**0.001**

**Confidence intervals and odds ratios could not be generated for consumption of nuts/seeds and pulses.*

Figures

Fig. 3.1. Map of the study region of Sulawesi and the Spermonde Islands (shown by the arrow) with the study site of Bontosua Island labeled. Much of the fish caught by islanders on Bontosua is traded in regional fishing ports located in the city of Makassar.

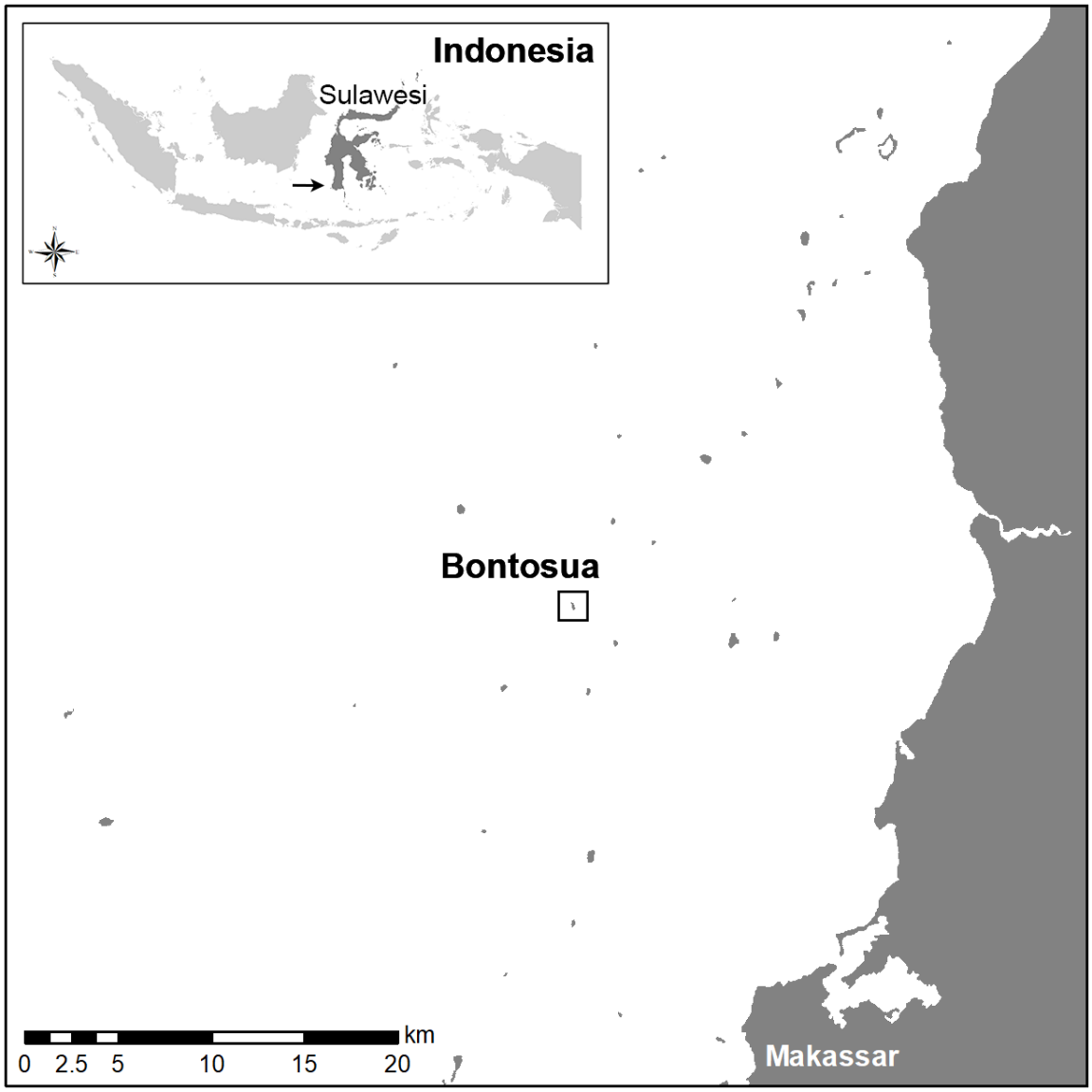
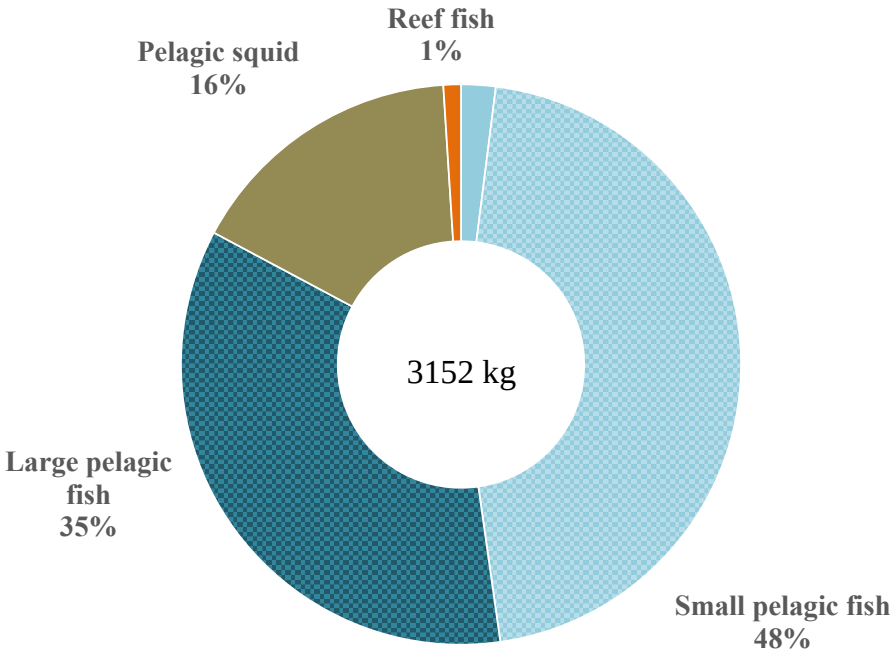


Fig. 3.2. Total amount by fish type captured by Bontosua fishing crews (patterned) and independent fishers (solid) on a typical day in the (a) calm and (b) windy seasons. Pie chart size is roughly proportional to the amounts harvested in either season.

(a) Calm



(b) Windy

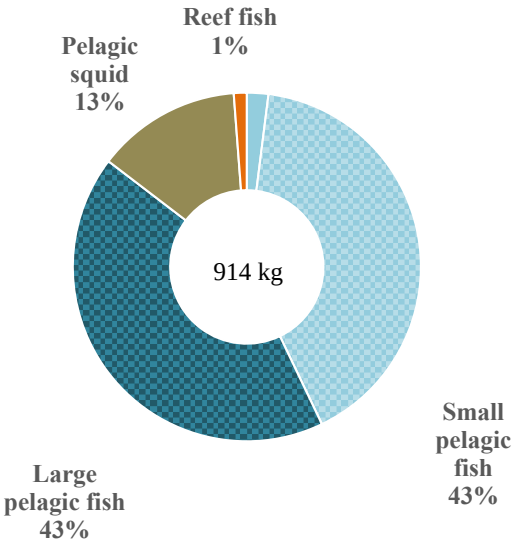


Fig. 3.3. Total amount of fish consumed, in kg, by surveyed households (*N*=62) on a typical day during the calm and windy season.

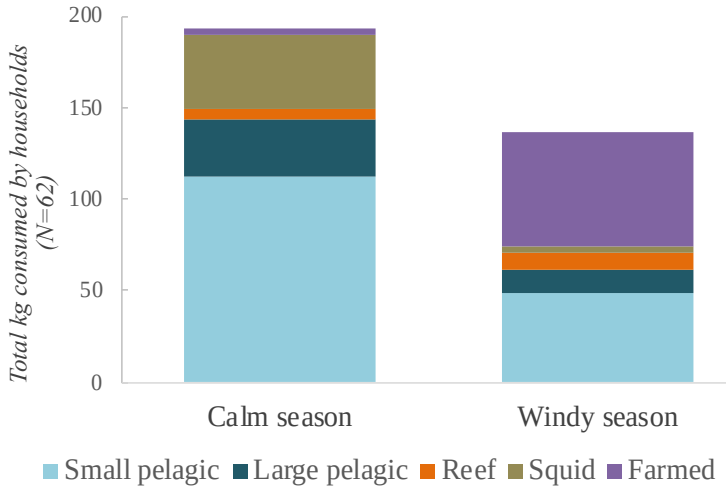


Fig. 3.4. The first pie chart shows the total amount of fish consumed by all households surveyed (*N*=62), in kg, on an average day during the windy season. All remaining pie charts represent the division of pathways summing to the total. Next, the pathways for acquiring the fish for households are shown with their relative proportion purchased versus acquired for free. The last three pie charts depict the relative proportion of fish purchased from various fishers and traders on the island. All pie charts are stratified by fish type.

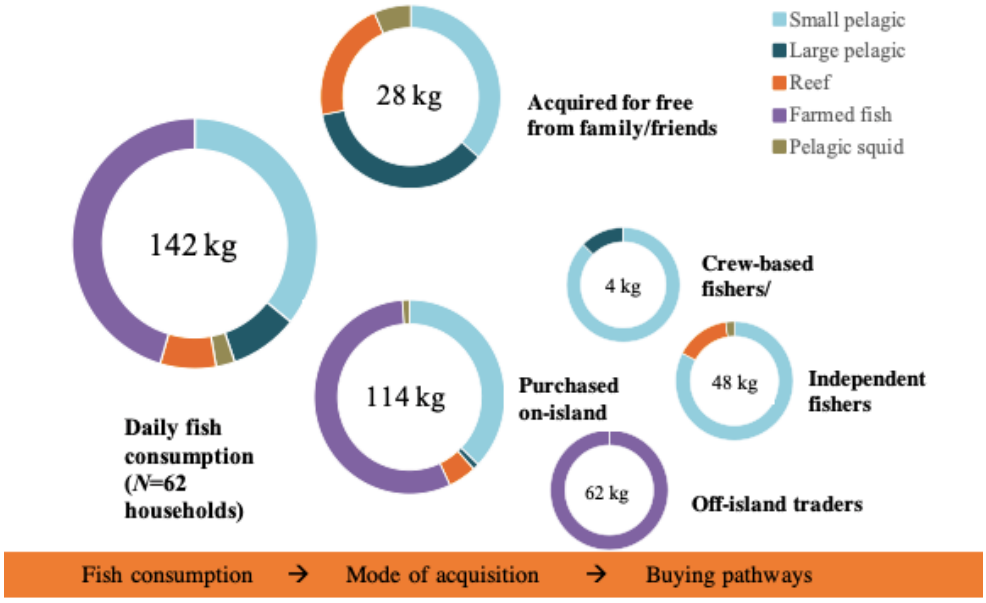


Fig. 3.5. Boxplots with median (horizontal line), mean (x), and quartiles (box ends) of market prices of fish species caught and/or consumed in the (a) calm and (b) windy season. Error bars represent one standard deviation from the mean.

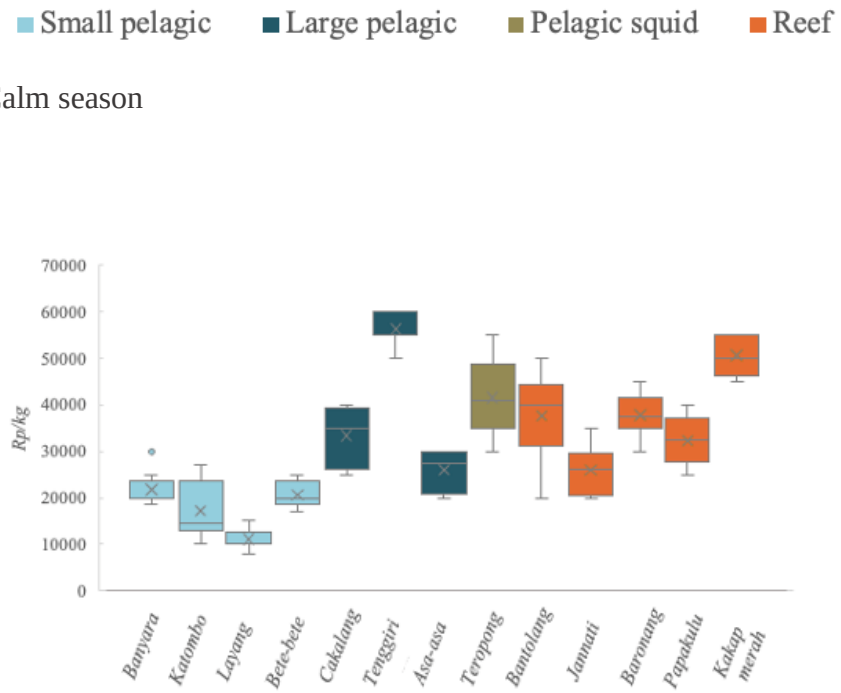


Fig. 3.6. Level of importance indicated by consumer rankings of fish consumed against the consumption level of the species (number of households consuming in either the calm or windy season). Importance was subjective; according to the survey notes, the ranking criteria used by respondents was based on taste or frequency of consumption.

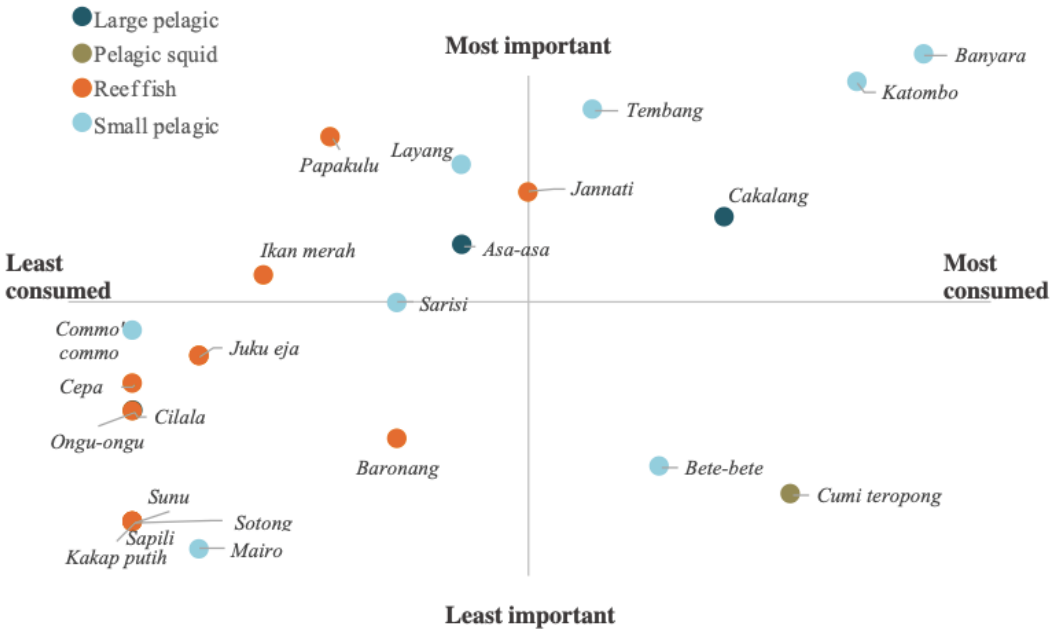


Fig. 3.7. Food groups consumed by consumers who had achieved dietary diversity (*N*=36) and those who had not (*N*=19). Results were based on a 24-hour recall of food intake. The proportion of consumers is based on the N values for each group.

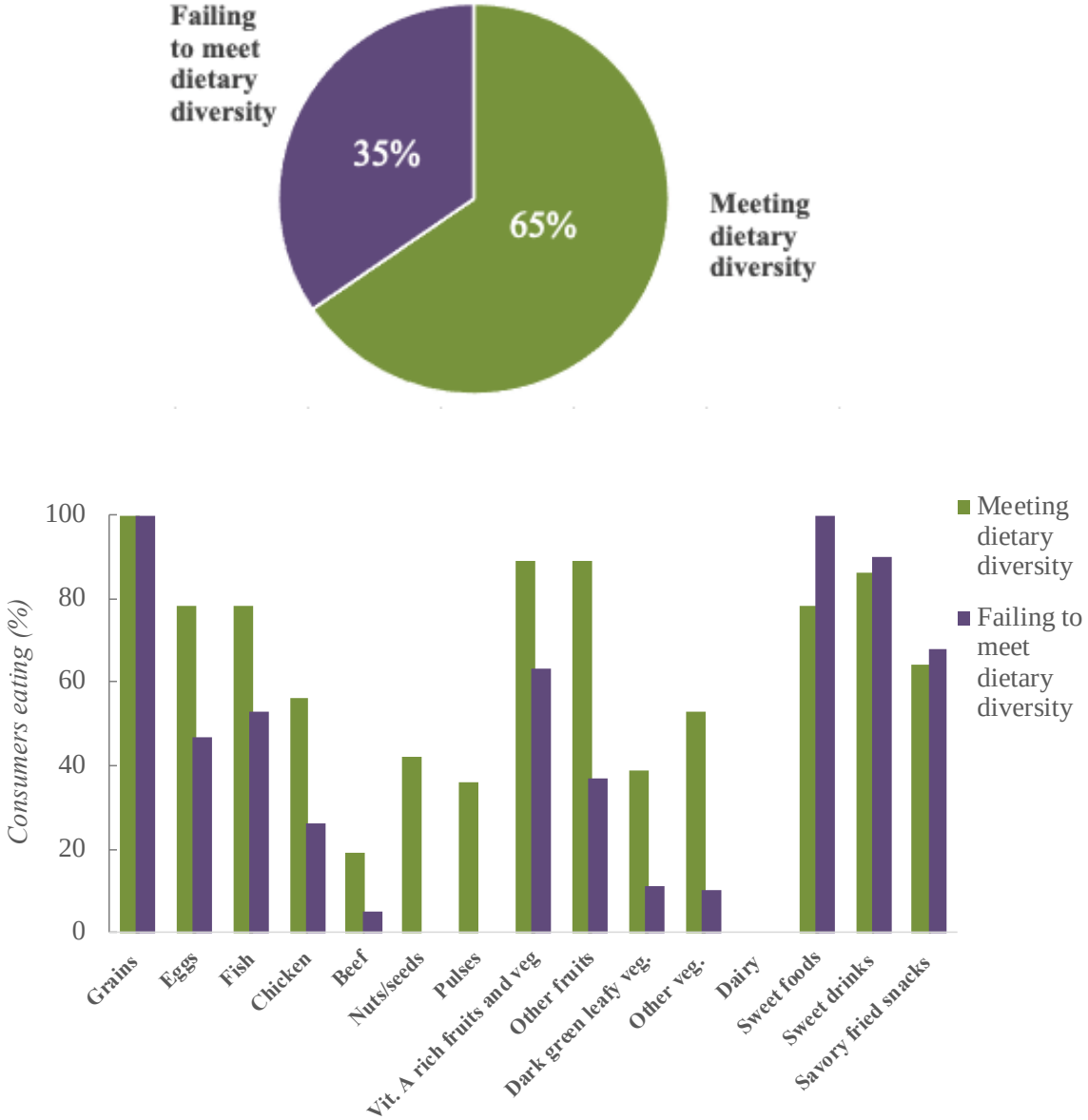
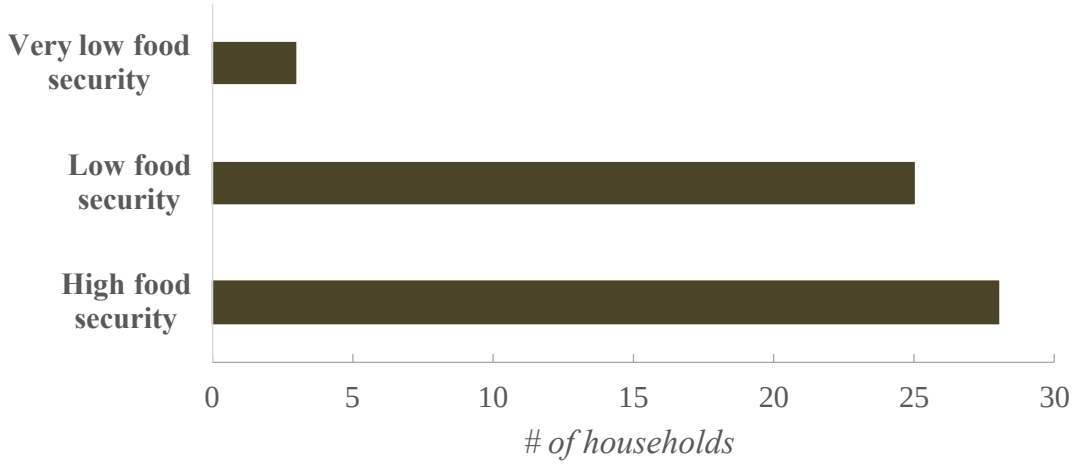


Fig. 3.8. Level of food security experienced by households (*N*=62) in the previous thirty days.



CHAPTER IV: Conclusion

Fisheries have been identified as critical to achieving food and livelihood security in coastal developing countries (Bene et al. 2019, Farmery et al. 2021). In Indonesia, the benefits produced by fisheries coupled with the threats they face have given rise to networks of management and conservation organizations with dual ecological and social goals. For instance, a coral reef restoration (CRR) project taking place on Bontosua Island outlines food and livelihood security as stated objectives. However, many interventions including CRR often fail to satisfy community-based needs because they focus on technical parameters at the harvest end of the value chain such as fish price and income (Matthews et al. 2012, Giakoumi et al. 2018, Hein et al. 2019). As this research contends, access to and utilization of specific species of fish mediate connections between fisheries and food security. By tracking harvest, trade, and consumption originating from a small Indonesian fishing community, we found a reliance on small pelagic fish linked to socio-economic hierarchies throughout the value chain. Our results offer several opportunities for practitioners involved in the CRR project on Bontosua, and other fisheries enhancement projects in the region, to better account for local well-being and food security needs.

At a time where marine use conflicts are mounting, there is an increasing need to manage tradeoffs in management objectives (Clifton and Foale 2017, Warren and Steenbergen 2021). Conservation outcomes that can be characterized as “biological” successes and “social” failures occur because of a poor grasp on the social complexities within a system (Christie 2004, Chuenpagdee et al. 2013). For this reason, conservation - practitioners in community settings may be better positioned to bridge broader

management goals and community needs. Indeed, the goals set by the CRR project are in line with the issues of equity and dietary deficiencies outlined in Chapter 2 and Chapter 3. However, given the heterogeneous landscape of community actors and their roles identified in this study, the conservation directive should be aware of a number of possible tradeoffs with their coral restoration strategy.

This research observed a lack of cohesion between the focus of a conservation project on enhancing reef-based fishing and the composition of the island community's catch, trade, and consumption. **Chapter 2** identified socio-economic hierarchies extending from fishers on the island to traders in Makassar that drove the movement of fish off-island. From catch to sale in Makassar, there was limited dependency on coral reef resources, and fishing was primarily financed through loans from pelagic crews: a hierarchical fishing format supported by debt-based ties between a patron (lender) and client (debtor). Debt helped to shape key bottlenecks, including, i.) tapered supply chains characterized by inflexible trading relationships; ii.) disproportionate value accumulation by on and off-island patrons. Fishers and traders indebted to other actors in the value chain had limited trading connections and flexibility in their existing trading relationships. Capital ties and mobility are closely interlinked in fisheries (Crona and Bodin 2010, Deswandi 2012, Drury O'Neill 2019); therefore, given the strong relationship between debt and pelagic crew-based fishing, achieving more sustainable livelihoods through the increased practice of reef-based fishing alone would be difficult on Bontosua. We instead urge partners to consider community perspectives and relationships to the fish trade (Nurdin and Grydehoj 2014, Lowitt et al. 2019). Other research has shown that the community in question values reefs mainly for storm

protection rather than for fishing (Vandenberg et al. 2021). Leveraging these needs, in addition to addressing familial and debt-based relationships on-island, could help to unlock community-wide benefits from fisheries management interventions.

Small pelagic fish were the most commonly caught, traded (on-island and off; **Chapter 2**), and consumed fish group, and also the least expensive on the market. We found in **Chapter 3** that access to avenues for fish and certain species was mediated by seasonal fluctuations: during the monsoon and full moon ("windy" season), consumer households must buy farmed fish from off-island traders, or choose from a limited selection of nearshore reef and pelagic fish caught by independent fishers. During this time, vulnerability to food insecurity increases, as overall fish consumption declines, fish buying increases, and households substitute with cheaper and less nutritious foods. Moreover, households preferred eating small pelagic fish over any other fish group. Taken together, tackling food insecurity in the Spermonde region requires greater investment in the management of small pelagic stocks, as well as credit alternatives for vulnerable periods that do not rely exclusively on patron support.

Regarding the conservation initiative's goal of enhancing food security through reef fishing, there exists opportunity to strengthen community ties to small-scale fisheries. Evidence from **Chapter 3** suggests that fish buying pathways with small-scale fishers-- including all reef fishers on the island-- are critical during vulnerable periods. Throughout Southeast Asia, the contribution of small-scale fisheries to food security is substantial (Chuenpagdee et al. 2006, Teh and Pauly 2018). However, in the advance towards industrial fishing, user conflicts have displaced many small-scale fishers in Indonesia (Cohen et al. 2019, Smith and Basurto 2019). For a community-based reef

project to see success in livelihoods and nutrition, strengthening inshore marine tenure should become a priority at a local level. This has already proven difficult on the study island, where unclear rules and restrictions around coral reef fishing since the project's implementation have placed strains on island relations (Vandenberg et al. 2020). While granting equitable access to small-scale fishers remains a key question for research and policy, scholars agree that improved user rights are key action items to be undertaken by conservation in the region (Glaser et al. 2010, Radjawali 2012). We identified in **Chapter 2** that a minority group of small-scale fishers reported catching reef fish. Access to and proper management of coral reefs and fair allocation of benefits could increase self-sufficiency, particularly during the windy season as islanders must rely on less preferred farmed fish. By amplifying the roles of small-scale fishers- through gear provisioning, reef stewardship education, supportive measures for small-scale fishing and on-island trade during the windy season, trade mechanisms to minimize debt-based relationships, and formal user rights for Bontosua's coral reef areas- the community as a whole could take better advantage of the food security benefits offered by the surrounding coral reefs.

If the CRR project were able to recruit more islanders in small-scale coral reef fishing and work with the local and regional governments to provide appropriate access and support, then it is possible that more households could take advantage of enhanced reef fish populations. However, a shift in fishing demographics could also compromise benefits at the household level. Even though small-scale fishing is important for on-island sale, small-scale fishers provide a smaller proportion of fish overall to consumers, and reef fish in particular (Chapter 3). Were it not for the more efficient and larger catch capacity of crew boats (Pet-Soede et al. 2001), surplus catch may be less accessible to

households. Furthermore, a large international market for high-value reef fish from the Spermonde (e.g. Ferse et al. 2012, Ferse et al. 2014) brings into question the likelihood that reef fish would be utilized as an on-island supplement or replacement for the less preferred farmed fish.

Finally, our **Chapter 3** conclusions on income-based food security, combined with illustrations of the patron-client system in **Chapter 2**, suggest that addressing the basis and distribution of trading benefits, rather than altering harvest methods and fish targets themselves, could be transformative for food security outcomes. Doing so would require integrating strategies across multiple sectors to address linked issues of livelihood and food insecurity and malnutrition. For community conservation projects to enhance food security with harvest, their potential to alter the existing trading structure and consumption pathways must be weighed against the proposed benefits.

Consideration of women in coastal communities has failed to become a priority in marine management, even as rapid social and ecological change exposes their important and vulnerable positions in the value chain (Matthews et al. 2012, Harper et al. 2017). Women on Bontosua are responsible for managing the household and purchasing food for their families. They are knowledgeable about methods of preparation, consumption patterns, and exhibit preferences for certain fish which influence their acquisition patterns. Because preferences and customs can help steer the cultural and social alignment of a project, they have an important place in assessments (Noack and Pouw 2015, Giakoumi et al. 2018).

Our findings suggest that fishing modes, trading structure, and consumption patterns are closely related; therefore, the value chain's complexity demands a more

holistic approach to livelihoods that extends beyond a singular focus on production. Future work could benefit from a more varied interpretation of value, as the ways in which fish are exchanged, utilized, and perceived matter in the context of food security. Our conclusions caution against viewing the reef restoration program as a catch-all system; CRR is unlikely to generate long-lasting social-ecological benefits unless project practitioners engage in further collaboration with community members and governments, and place a stronger emphasis on Bontosua livelihoods.

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